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ABSTRACT

This curriculum guide is intended to continue students' training in the auto body trade by providing instruction in the specialty area of frame repair. It complements the other manuals that cover body repair and refinishing. Suitable for secondary, postsecondary, and adult classes, this guide is easily adaptable to open-entry, open-exit programs to allow students to progress at an individual pace. This curriculum guide contains four units with eight basic components for each unit: performance objectives, suggested activities for the teacher, information sheets, assignment sheets, job sheets, transparency masters and supplements, tests, and answers to tests and assignment sheets. (Depending on the specific objectives, there may or may not be transparency masters, supplements, assignment sheets, or job sheets included in the unit of instruction.) All of the unit components focus on measurable and observable learning outcomes and are designed for use in more than one lesson or class period of instruction. The following skills are covered in the four units: gauge and analyze frame damage, align frame, align suspension and steering components, and replace structural panels. (KC)

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Automotive Frame Repairer

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FOREWORD

In Oklahoma, vocational educators have a basic belief that quality vocational programs require the use of sound instructional materials. A comprehensive approach with a quality treatment served as the primary approach when the Oklahoma State Department of Vocational and Technical Education, Curriculum and Instructional Materials Center began revisions of its instructional guide for the auto-body trade. This volume, *Automotive Frame Repairer*, provides students in this area with an overview of the duties, procedures, concepts, tools, and equipment used in frame repair. It supplements the first volume of this series, *Introduction to Auto Body*, and complements the other manuals that cover body repair and refinishing. Throughout the series, every effort has been made to address the latest in technology with a special concern for the safety and health aspects associated with auto-body occupations.

Industry representatives, educators, and technical specialists collaborated closely to produce these materials in the hope that students will gain the knowledge and skills required in the auto-body trade through practical learning experiences. Coupled with the instructor's own methods and expertise, the materials should prove to be a valuable asset for a progressive auto-body training program.

It is our sincere wish that the manuals in this series will contribute to the development of a competent, safety-conscious work force in the auto-body trade.

Roy Peters, Jr., Director
Oklahoma State Department of
Vocational and Technical Education

Ivan Armstrong, State Supervisor
Trade and Industrial Education
Oklahoma State Department of
Vocational and Technical Education

PREFACE

The purpose of *Automotive Frame Repairer* is to continue the student's training in the autobody trade by providing instruction in this specialty area. Instructional materials are also being developed for body repair, refinishing, and shop management. Each volume has been carefully reviewed and validated by a committee of industry and education representatives concerned with presenting the latest advances of the trade.

These curriculum materials have been designed for use in full-time secondary and post-secondary classes, as well as part-time adult classes. The material is easily adaptable to open-entry, open-exit programs to allow students to progress at their individual paces.

A skilled instructor will be able to supplement, personalize, and localize this material to meet specific training needs. The design of the material allows the different topics to be presented in a variety of sequences, and even permits the use of part of a unit of instruction at a given time. The "Use of this Publication" section will greatly aid the instructor and student in getting the most from these materials. Additionally, the CIMC staff will be glad to assist you in tailoring these materials to your needs.

Bob Patton, Coordinator
Curriculum and Instructional
Materials Center
Oklahoma State Department of
Vocational and Technical Education

ACKNOWLEDGEMENTS

Any project as comprehensive and involved as this guide for teaching auto-body repair requires the contributions of a great number of people. I am thankful for the tremendous support I have received in the development of this book.

Throughout the development of this book, I was guided by an able panel of experts from both the industry and education. This committee designed the scope and sequence of all the materials contained in this series and reviewed the completed materials for technical accuracy, teachability, currency, and industry relevance. I am especially grateful for the assistance given by representatives of the Independent Automotive Service Association and the Inter-Industry Conference on Automotive Collision Repair (ICAR). The review committee included

Mike Avant
Auto-Body Instructor
Indian Meridian Area
Vo-Tech School
Stillwater, Oklahoma

Jim Blankenship
Zone Chairman ICAR
Owner and President
Jim Blankenship Body Shop
Tulsa, Oklahoma

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Pryor, Oklahoma

Ron Wood
Owner and President
R and M Body Shop
Chickasha, Oklahoma

I owe a great deal of gratitude to members of the Oklahoma State Department of Vocational and Technical Education staff who made the project possible, especially to Roy Peters, Jr., State Director; Ivan Armstrong, Trade and Industrial State Supervisor; and Bob Patton, CIMC Coordinator. These men recognized the need for these materials and dedicated the resources to see that the project was completed. I gratefully recognize the contributions of Dean Myers, who represented the Trade and Industrial Division, and Susan Walker, who assisted with this project while coordinating production and co-authoring other books in this series.

I am also thankful to the many people involved in the production process. I received editorial guidance and assistance from the editing staff, supervised by Terri Barnes; thanks to Sue Buck, Jerry Weir, and Marsha Sneed. I am also grateful to those in the Communications Center, under Debbie Hixson, who prepared the many drafts of this manual, with special thanks to Rose Primeaux, Stephanie Shipley, and Lisa Tomlinson.

The illustrations for this publication came from a number of sources. The CIMC is thankful to the many companies and publishers who contributed artwork, identified by the permission lines accompanying many of the illustrations. We are also grateful for the work done by the Art Department, under Bob Davis, and especially to Gary Bradley, Kim Hale, Kathryn Hansen, Robert Randall, and Scott Stone, who served as illustrators on this project. Recognition also is due to Dana Cole of the CIMC Media Unit who did the photographic work for this volume.

The quality of the published product is the result of the care and talents of the Print Shop personnel under the supervision of Noel Wilcoxson. None of this would have been possible without the dedication and skills of the CIMC secretarial staff under Judy DeVaughan, and especially the assistance of Janette Nicholson, secretary to the Development Unit. To these and many others, I am extremely grateful to have shared in this team effort.

It is my sincere hope that these materials will be of value to auto-body instructors and that they benefit those students who pursue careers in this vital and rewarding field.

Robert Hilley

Instructional Units

Automotive Frame Repairer contains four instructional units. A standard format was established in 1970 for development of instructional materials for all Oklahoma vocational teachers. This format includes eight basic components that form a unit of instruction: performance objectives, suggested activities for the teacher, information sheets, assignment sheets, job sheets, transparency masters and supplements, tests, and answers to tests and assignment sheets. Depending on the specific objectives, there may or may not be transparency masters, supplements, assignment sheets, or job sheets included in the unit of instruction.

All of the unit components "zero in" on measurable and observable learning outcomes. Teachers are encouraged to supplement, personalize, localize, and motivate with these materials in order to develop a complete teaching/learning process.

Units of instruction are designed for use in more than one lesson or class period of instruction. Careful study of each unit of instruction by the teacher will help him or her determine the following

- Amount of material that can be covered in each class period
- Skills that must be demonstrated
  - Supplies and equipment needed
  - Amount of practice needed
  - Amount of class time needed for demonstrations
- Supplementary materials, such as pamphlets and filmstrips, that must be ordered
- Resource people to contact

Performance Objectives (white pages)

Each unit of instruction is based on the performance needed for successful employment in an occupational area. Performance objectives are stated in two forms: unit objectives, stating the subject matter to be covered in a unit of instruction; and specific objectives, stating the performance necessary to reach the unit objective. Since the objectives of the unit provide direction for the teaching/learning process, it is important that teachers and students have a common understanding of the intent of the objectives.

The objective sheet should be given to students and referred to throughout the teaching/learning process. This will help answer any questions concerning performance requirements for each instructional unit. The objectives can also help determine teaching strategies and instructional methods. Prepare for each unit by deciding how each objective can best be taught.

The objective sheet may also be used as a quick pretest to determine students' prior knowledge and to determine whether further study or activities are necessary. Teachers should feel free to modify, delete, or add objectives in order to meet the needs of the students and community. When changes in objectives are made, the teacher should remember to supply the needed information, assignment and/or job sheets, and criterion test items.

Suggested Activities (pink pages)

Suggested activities are included only in teacher materials. The suggested activities pages include an outline of the unit contents and an instructor's guide designed to assist teachers in planning their presentation of the unit. The instructor's guide provides suggestions for delivery and/or presentation during the instructional process. Read the suggested activities before teaching the units so that supplemental materials can be obtained, audiovisual materials prepared, and outside resources contacted. Duties of the teacher will vary according to the particular unit.

The references that are listed in the suggested activities are ones used in the development of each unit. They may be used by the teacher to supplement her or his knowledge of the subject area or to help students with particular interests or occupational objectives in the area covered.

The suggested activities section of the unit also includes supplements and transparency masters. Each of these components provides information in a special way. Supplements may consist of motivational materials, review or practice materials such as crossword puzzles and self-tests, or charts and reference materials. Supplements are designed to be copied and distributed to individual class members or to the class as a whole. Suggestions for their use are included in the instructor's guide. Transparencies direct the class' attention to the topic of discussion. Transparencies may present new information, or they may reinforce information presented in the information sheet. They are particularly effective when identification or analysis is necessary. Order transparencies from the Curriculum and Instructional Materials Center, or make transparencies and place them in the notebook where they will be immediately available for use.

Information Sheet (green pages)

The information sheet provides "must know" content essential for meeting the cognitive (knowledge level) objectives of the unit. The information is written in a topical-outline form and is keyed to the specific objectives.

Teachers will find that the information sheet serves as an excellent guide for presenting background knowledge necessary to develop the skills specified in the unit objective. The information sheet may also be used for coordination activities and advisory committees.

Students should read the information sheet before the information is discussed in class. Space is provided in margins for students and teachers to add notes that supplement, localize, personalize, or provide motivation for each unit.

Assignment Sheets (brown pages)

Assignment sheets give students a chance at problem solving, self-assessment, and/or practical experience. They assist students in the application of knowledges that are necessary prerequisites to skill development. Assignment sheets may be given to the student for completion in class or may be used for homework assignments. Answer sheets are provided when appropriate and can be used by the student and/or teacher for checking student progress. The scores of those assignment sheets listed in the specific objectives should be averaged with the unit test score, as the skills addressed in these assignment sheets are considered necessary in meeting the unit objective.

Job Sheets (blue pages)

Job sheets are another important segment of a unit of instruction. The job sheets provide a list of equipment, tools, and materials needed to complete a manipulative or psychomotor skill. They describe a step-by-step procedure needed to complete each task or job. Diagrams, photographs, and illustrations are provided to assist students in achieving the skill.

The teacher should demonstrate to students the procedures outlined in each job sheet. Furthermore, the teacher needs to localize the job sheet according to the equipment and supplies available in the local lab or shop situation. Job sheets also furnish potential employers with a picture of the skills being taught and the performances they might reasonably expect from a person who has had this vocational instruction.

Job sheet performance should be evaluated by the instructor and averaged with the unit test score, as the skills addressed in the job sheets are considered necessary in meeting the unit objective.

Tests (yellow pages)

The test provides criterion-referenced evaluation of every objective listed in the unit of instruction. It is crucial to note that both paper/pencil and performance objectives must be evaluated.

It is recommended that the tests be divided into shorter tests covering three or four objectives at a time and given soon after those objectives have been covered. A selection of questions from the units covered may be used for final tests at the end of each term if desired. If objectives have been added, deleted, or modified, be sure to make the changes on the test.

The acceptable response on a unit test, 85 percent in most units, may be raised or lowered to fit the topic or students' ability levels. The percentage applies to the overall score, not to each question. The final unit grade should be obtained by using the paper/pencil score and evaluations of student demonstrations of the desired skills.

Answers to Test and Assignment Sheets (pink pages)

Answers to test and assignment sheets are components designed to assist the teacher in evaluation of student performances.

Page Numbering

Each publication from the Curriculum and Instructional Materials Center (CIMC) is assigned a specific abbreviation. For example, *Automotive Frame Reparier* has been abbreviated FR. The units are then numbered consecutively within each section. An example of a page number is FR 1. Since CIMC publications are loose leaf, this system of page numbering was adopted so that pages from different manuals would not get mixed up.

Methods of Disseminating Material

Material may be given out a unit or page at a time to keep the material before the student always new. Some teachers ask students to furnish a three-ring binder for the units. This is convenient for taking the materials home to study. Upon completion, each unit is then placed in a larger binder. The large binders may be purchased at cost from the CIMC. Some teachers store the materials by units in filing cabinets or boxes until needed. All the units may be given out at once if desired.

For best results, provide student materials for each student. Student materials contain everything but the test answers, answers to assignment sheets, and suggested activities. All tests are collated at the back of student material and should be removed and stored until needed.

Teaching Methods

It is a challenge to keep students motivated. Supplement the objectives by providing the "why," personal experiences, and current information. Prepare for each unit by deciding how each objective can best be taught. Allow students to become involved in preparing and planning.

Competency Profiles

Competency profiles are folders used to document student performance. The profile contains a list of the specific job competencies that a student should achieve prior to leaving the training program. Competency profiles may be ordered from the State Department of Vocational and Technical Education, Curriculum and Instructional Materials Center, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074.

CORRECTIONS AND SUGGESTIONS

The Curriculum and Instructional Materials Center (CIMC) wants to provide vocational instructors and students with materials that are accurate and effective. Although the CIMC strives to maintain the highest standards of development and production, oversights occasionally do occur. If you find any errors in this or other CIMC publications, or have suggestions for improving their usefulness in vocational programs, please notify the CIMC staff. One easy way of pointing out errors is to make a photocopy of the affected page and to indicate the correction on the copy. You can mail the information to the CIMC, where it will be used to correct the publication before the materials are reprinted.

To ensure that the material is updated on a timely basis, it is important that you notify the CIMC of necessary corrections as soon as possible after discovering the error. Do not assume that someone else will notice the error and inform the CIMC; other users may be making the same assumption. Please send corrections and recommendations for improving this publication to the following address:

Manager of Development
Curriculum and Instructional Materials Center
Oklahoma State Department of Vocational and
Technical Education
1500 West Seventh Avenue
Stillwater, Oklahoma 74074

GAUGE AND ANALYZE FRAME DAMAGE
UNIT I

UNIT OBJECTIVE

After completing this unit, the student should be able to gauge and analyze various types of damage involving a variety of frame and unitized body designs. The student will show this ability by completing the assignment sheets, job sheets, and unit test with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match to their correct definitions terms associated with gauging and analyzing.
2. Identify types of frames.
3. Label parts of common types of frames.
4. Match reference elements of damage analysis to their correct descriptions.
5. List the elements of damage analysis shown in representations of structural damage.
6. Identify types of frame and unitized body damage.
7. Label frame repair control points on illustrations of frame and unitized body designs.
8. Identify equipment used in gauging damage.
9. Label the parts of a centering gauge.
10. List methods of installing centering gauges.
11. Use centering-gauge alignments to identify types of damage.
12. Select from a list guidelines for installing centering gauges.
13. Label the parts of a tram gauge.
14. Label parts of a universal bench.
15. Arrange in order the sequence for analyzing damage.
16. Use specification guides to determine gauging dimensions.

OBJECTIVE SHEET

17. Demonstrate the ability to

    a. Clean and calibrate a centering gauge.

    b. Prepare vehicle for gauging and analysis.

    c. Position vehicle on bench.

    d. Gauge and analyze diamond.

    e. Gauge and analyze twist.

    f. Gauge and analyze sidesway.

    g. Gauge and analyze sag.

    h. Gauge and analyze mash.

    i. Measure frame member distortion.

GAUGE AND ANALYZE FRAME DAMAGE
UNIT I

SUGGESTED ACTIVITIES

I. Unit contents

A. Objective sheet

B. Suggested activities

C. Supplements

1. Supplement #1 — Specifications for 1984 Ford Thunderbird
2. Supplement #2 — Specifications for 1983 Volkswagen Rabbit
3. Supplement #3 — Specifications for 1986 Chrysler Products
4. Supplement #4 — Specifications for 1986 Camaro

D. Transparency masters

1. TM #1 — Alignment of Centering Gauge
2. TM #2 — Conventional Frames
3. TM #3 — Unitized Body Frame
4. TM #4 — Combination Frame
5. TM #5 — Parts of a Perimeter Frame
6. TM #6 — Perimeter Frame Overlay
7. TM #7 — Parts of a Unitized Body
8. TM #8 — Unitized Body Overlay
9. TM #9 — Parts of a Combination Frame
10. TM #10 — Combination Frame Overlay
11. TM #11 — Three-Section Box Representation
12. TM #12 — Three-Section Box Overlay
13. TM #13 — Centering Gauge Alignments
14. TM #14 — Overlay for Undamaged Vehicle

SUGGESTED ACTIVITIES

15. TM #15 — Overlay for Sidesway
16. TM #16 — Overlay for Diamond
17. TM #17 — Overlay for Sag
18. TM #18 — Overlay for Mash
19. TM #19 — Overlay for Twist

E. Information sheet

F. Assignment sheets

1. Assignment Sheet #1 — Analyze Body-Frame Damage
2. Assignment Sheet #2 — Use Specification Guides to Determine Gauging Dimensions

G. Answers to assignment sheets

H. Job sheets

1. Job Sheet #1 — Clean and Calibrate a Centering Gauge
2. Job Sheet #2 — Prepare Vehicle for Gauging and Analysis
3. Job Sheet #3 — Position Vehicle on Bench
4. Job Sheet #4 — Gauge and Analyze Diamond
5. Job Sheet #5 — Gauge and Analyze Twist
6. Job Sheet #6 — Gauge and Analyze Sidesway
7. Job Sheet #7 — Gauge and Analyze Sag
8. Job Sheet #8 — Gauge and Analyze Mash
9. Job Sheet #9 — Measure Frame Member Distortion

I. Test

J. Answers to test

II. Instructor's guide

A. Review unit and plan presentation.

SUGGESTED ACTIVITIES

B. Order or obtain materials needed to teach unit.

1. Media

(NOTE: The programs listed below are available from Teaching Aids Incorporated, Post Office Box 1798, Costa Mesa, California 92628-0798.)

a. *Body and Frame Construction*, media with worksheet

b. *Frame Damage Analysis and Correction*, media with worksheet

(NOTE: Many vehicle manufacturers have media depicting their crash tests. Other media showing crashes are available from publications such as *Motor Week*.)

2. Media equipment

3. Variety of equipment used in gauging damage

4. Equipment and materials needed for job sheet performance

5. Access to various types of frame and unitized body designs

6. Specification guides for gauging dimensions

7. Media and literature from bench equipment manufacturers

8. Transparencies and competency profiles

(NOTE: Transparencies and competency profiles for this manual are available from the State Department of Vocational and Technical Education, Curriculum and Instruction Materials Center, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074.)

C. Provide students with unit.

D. Introduce unit.

SUGGESTIONS:

- Use Transparency #1 or actual centering gauges to discuss the meaning of gauging and analyzing.
- Discuss unit and specific objectives, explaining that mastery of the specific objectives leads to accomplishment of the unit objective.
- Explain the importance of being able to gauge and analyze frame damage accurately.

SUGGESTED ACTIVITIES

E. Discuss information, assignment, and job sheets.

1. Use Information Sheet, Section I to introduce students to terms associated with gauging and analyzing frame damage.

   SUGGESTION:

   - Illustrate or show examples of appropriate terms.

2. Use Information Sheet, Sections II and III to discuss frame types and parts.

   SUGGESTIONS:

   - Show filmstrip *Body and Frame Construction.* Critique with the class.
   - Show students different types of frames on actual vehicles.
   - Have students identify frame parts on various makes and models of vehicles.
   - Use Transparencies #2-#4 to discuss types of frames.
   - Use Transparencies #5, #7, and #9 with overlays to discuss parts of frames. Remove the overlays to quiz the students on the names and locations of parts.

3. Use Information Sheet, Sections IV and V to discuss reference elements of damage analysis.

   SUGGESTIONS:

   - Show crash test films if available.
   - Stress that most damage cannot be categorized in terms of only one of the elements of damage.
   - Have students test their understanding of this material by completing Part A of Assignment Sheet #1.
   - Have students practice analyzing damage on actual vehicles in regard to reference elements.
   - Make models of the three box section representation to illustrate damage. Some instructors make such models from wire so that they can be distorted and reshaped.

4. Use Information Sheet, Sections VI and VII to discuss frame and unitized body damage and frame repair control points.

   SUGGESTIONS:

   - Use Transparency #11 and overlay to discuss control points.

SUGGESTED ACTIVITIES

- Show filmstrip *Frame Damage Analysis and Correction*. Critique with the class.
- Have students test their understanding of frame damage by completing Part B of Assignment Sheet #1.
- Have students identify damage and control points on actual vehicles.

5. Use Information Sheet, Section VIII to introduce students to the equipment used to gauge damage.

   SUGGESTION:

   - Show the students actual pieces of equipment; demonstrate how the equipment works when appropriate.

6. Use Information Sheet, Sections IX through XII to discuss and demonstrate centering gauges.

   SUGGESTIONS:

   - Discuss guidelines for installing centering gauges.
   - Use Transparency #1 to illustrate your discussion.
   - Have students identify the parts of an actual centering gauge. Explain the function of each part.
   - Demonstrate each of the methods of installing centering gauges. Allow the student to practice installing centering gauges on undamaged vehicles until they have mastered this skill.
   - Review types of damage depicted by the various centering gauge alignments.
   - Demonstrate Job Sheet #1 and allow student practice.

7. Use Information Sheet, Section XIII to introduce students to the parts of a tram gauge.

   SUGGESTIONS:

   - Demonstrate use of the tram gauge.
   - Have students practice using the tram gauge on undamaged vehicles until they have mastered this skill.
   - Have students identify the parts of an actual tram gauge. Explain the function of each part.

8. Use Information Sheet, Section XIV to discuss parts of a universal bench.

   SUGGESTIONS:

   - Use bench equipment in your shop or in nearby shops to discuss benches.
   - Explain why they are used and when they should not be used.
   - Provide students with media or literature from bench equipment manufacturers or get a representative to visit your shop.
   - Demonstrate Job Sheets #2 and #3 and allow student practice.

9. Use Information Sheet, Section XV to discuss the correct sequence for analyzing damage.

   SUGGESTION:

   - Have students complete Assignment Sheet #2. Critique and discuss with the class.

10. Demonstrate and discuss remaining job sheets. Assign job sheets and completion dates.

    SUGGESTION:

    - When assigning job Sheet #9, have all students measure the same vehicle independently of each other; compare results and discuss in class. Discuss how the measurements can be used in determining repair procedures and for checking results of repairs. Explain that some specification guides are developed this way, perhaps using 100 of the same model vehicle to arrive at averages.

F. Give test.

G. Critique test and discuss in class.

H. Reteach and retest as required.

I. Complete appropriate section of competency profiles.

III. Unit references

A. Coghlan, David A. *Automotive Chassis Systems: Steering, Suspension, Alignment, and Brakes*, 2nd ed. Boston: Breton Publishers, a division of Wadsworth, Inc., 1985.

B. Crouse, William H., and Donald L. Anglin. *Automotive Body Repair and Refinishing*, 2nd ed. New York: McGraw-Hill Book Company/Gregg Division, 1986.

SUGGESTED ACTIVITIES

C. *Gauging and Analyzing Collision Damage*. Grand Island, Nebraska: Chief Automotive Systems, 1978.

D. Manual, Edward F., and Wayman R. Penner. *Auto Body Repair and Repainting*. Stillwater, Oklahoma: State Department of Vocational and Technical Education/ Curriculum and Instructional Materials Center, 1974.

E. *The New Science of Unibody Repair*. Milwaukee, Wisconsin: Blackhawk Applied Power, Inc., Automotive Division, 1982.

F. Rhone, L. C., and H. David Yates. *Total Auto Body Repair*. 2nd ed. Indianapolis: Bobbs-Merrill Educational Publishing, 1983.

GAUGE AND ANALYZE FRAME DAMAGE
UNIT I

SUPPLEMENT #1 — SPECIFICATIONS FOR 1984 FORD THUNDERBIRD

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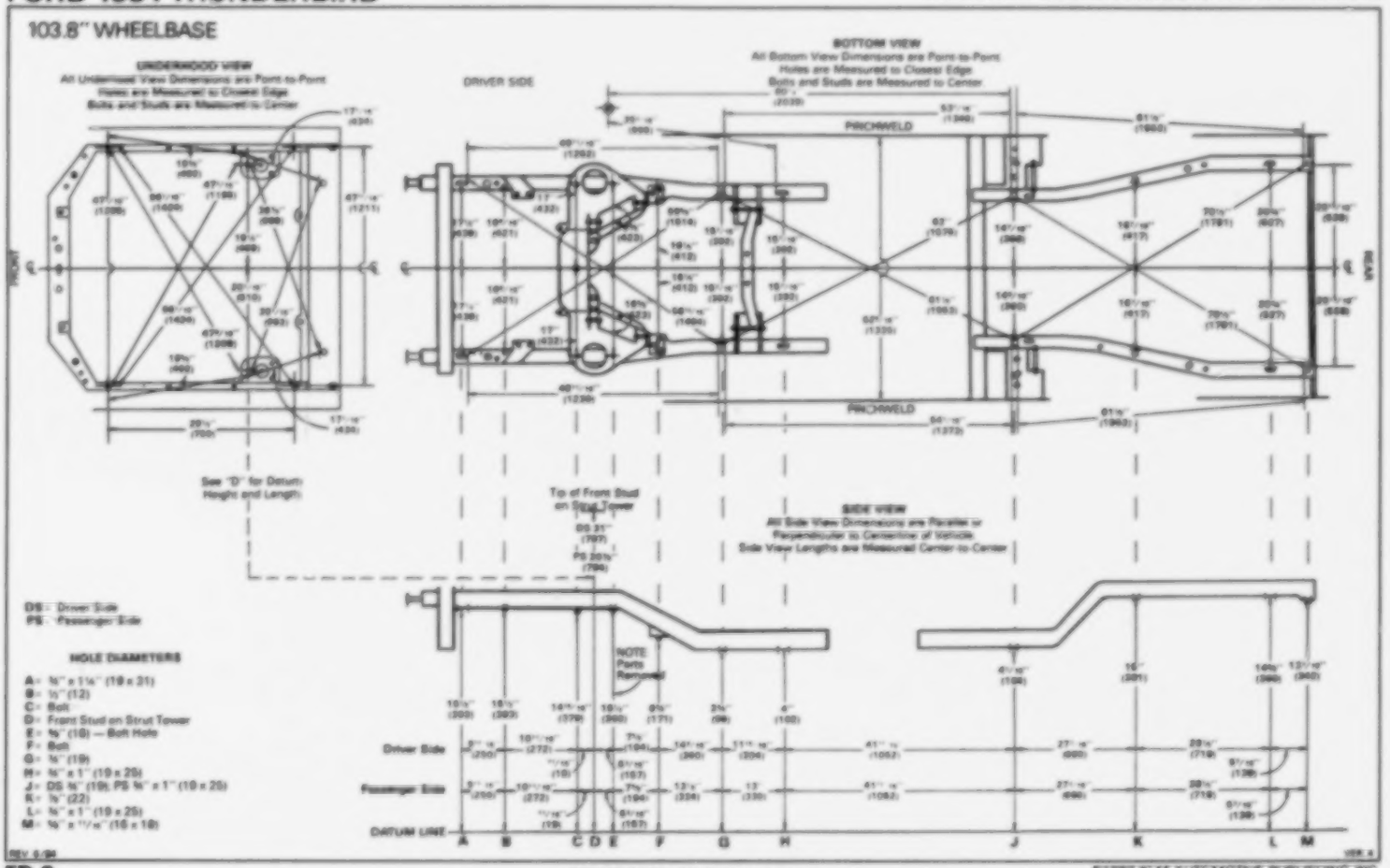
FORD 1984 THUNDERBIRD

UNIBODY AND CHASSIS DIMENSIONS AND SPECIFICATIONS

103.8" WHEELBASE


UNDERHOOD VIEW
All Underhood View Dimensions are Point-to-Point
Holes are Measured to Closest Edge
Bolts and Studs are Measured to Center
DRIVER SIDE
BOTTOM VIEW
All Bottom View Dimensions are Point-to-Point
Holes are Measured to Closest Edge
Bolts and Studs are Measured to Center
PINCHWELD
PINCHWELD
FRONT
REAR
See "D" for Datum Height and Length
Tip of Front Stud on Strut Tower
DS 31" (787)
PS 30⅞" (784)
SIDE VIEW
All Side View Dimensions are Parallel or Perpendicular to Centerline of Vehicle
Side View Lengths are Measured Center-to-Center
DS = Driver Side
PS = Passenger Side
HOLE DIAMETERS
A = ½" x 1¼" (19 x 31)
B = ½" (12)
C = Bolt
D = Front Stud on Strut Tower
E = ⅝" (16) — Bolt Hole
F = Bolt
G = ¾" (19)
H = ¾" x 1" (19 x 25)
J = DS ¾" (19), PS ¾" x 1" (19 x 25)
K = ⅞" (22)
L = ¾" x 1" (19 x 25)
M = ⅝" x 11/16" (16 x 18)
NOTE Parts Removed
Driver Side
Passenger Side
DATUM LINE
A B C D E F G H J K L M
REV. 6/84

FD-8

SEE PROCEDURE EXPLANATION

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GAUGE AND ANALYZE FRAME DAMAGE
UNIT I

SUPPLEMENT #2 — SPECIFICATIONS FOR 1983 VOLKSWAGEN RABBIT

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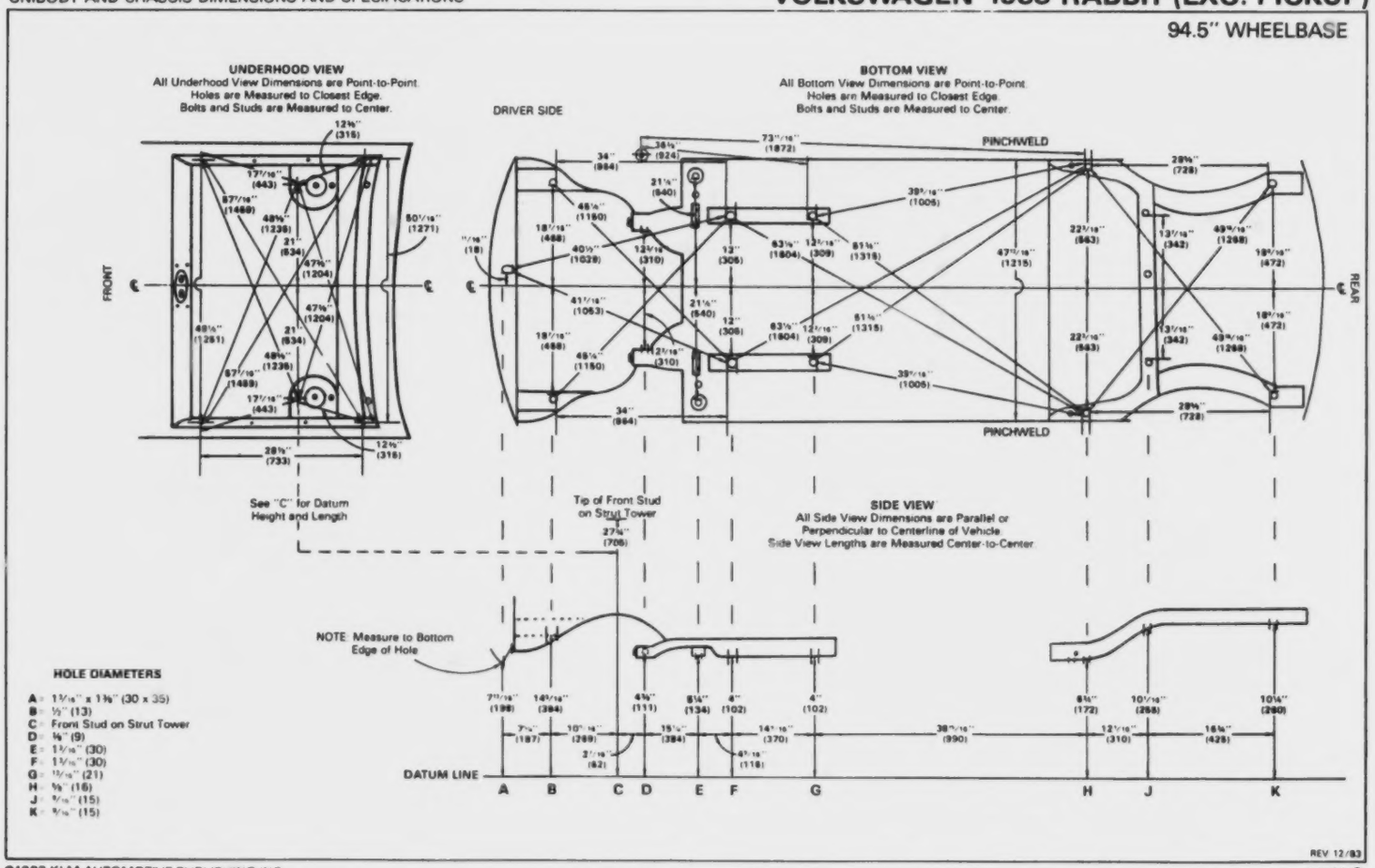
UNIBODY AND CHASSIS DIMENSIONS AND SPECIFICATIONS

VOLKSWAGEN 1983 RABBIT (EXC. PICKUP)

94.5" WHEELBASE


UNDERHOOD VIEW
All Underhood View Dimensions are Point-to-Point.
Holes are Measured to Closest Edge.
Bolts and Studs are Measured to Center.
FRONT
DRIVER SIDE
BOTTOM VIEW
All Bottom View Dimensions are Point-to-Point.
Holes are Measured to Closest Edge.
Bolts and Studs are Measured to Center.
PINCHWELD
REAR
See "C" for Datum Height and Length
Tip of Front Stud on Strut Tower
SIDE VIEW
All Side View Dimensions are Parallel or Perpendicular to Centerline of Vehicle.
Side View Lengths are Measured Center-to-Center.
NOTE: Measure to Bottom Edge of Hole
DATUM LINE
A B C D E F G H J K
HOLE DIAMETERS
A = 1 3/16" x 1 3/8" (30 x 35)
B = 1/2" (13)
C = Front Stud on Strut Tower
D = 3/8" (9)
E = 1 3/16" (30)
F = 1 3/16" (30)
G = 13/16" (21)
H = 5/8" (16)
J = 9/16" (15)
K = 9/16" (15)
REV. 12/83

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SEE PROCEDURE EXPLANATION

VW-3

GAUGE AND ANALYZE FRAME DAMAGE
UNIT I

SUPPLEMENT #3 — SPECIFICATIONS FOR 1986 CHRYSLER PRODUCTS

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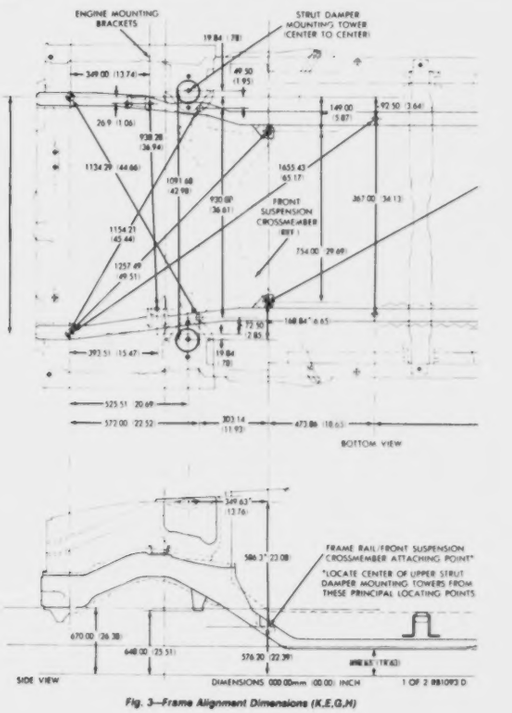
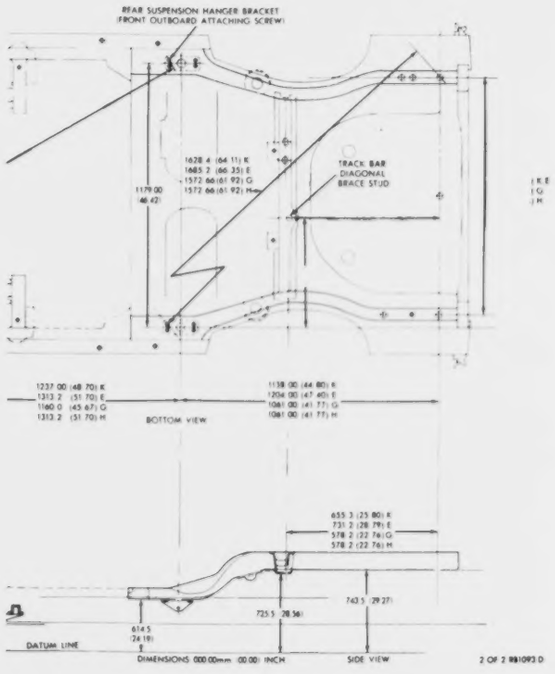

ENGINE MOUNTING BRACKETS
STRUT DAMPER MOUNTING TOWER CENTER TO CENTER
FRONT SUSPENSION CROSSMEMBER
BOTTOM VIEW
FRAME RAIL/FRONT SUSPENSION CROSSMEMBER ATTACHING POINT*
*LOCATE CENTER OF UPPER STRUT DAMPER MOUNTING TOWERS FROM THESE PRINCIPAL LOCATING POINTS
SIDE VIEW
DIMENSIONS 000.00mm .00.00 INCH
1 OF 2 RB1093 D

Fig. 3—Frame Alignment Dimensions (K,E,G,H)


REAR SUSPENSION HANGER BRACKET (FRONT OUTBOARD ATTACHING SCREW)
TRACK BAR DIAGONAL BRACE STUD
BOTTOM VIEW
DATUM LINE
DIMENSIONS 000.00mm .00.00 INCH
SIDE VIEW
2 OF 2 RB1093 D

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GAUGE AND ANALYZE FRAME DAMAGE
UNIT I

SUPPLEMENT #4 — SPECIFICATIONS FOR 1986 CAMARO

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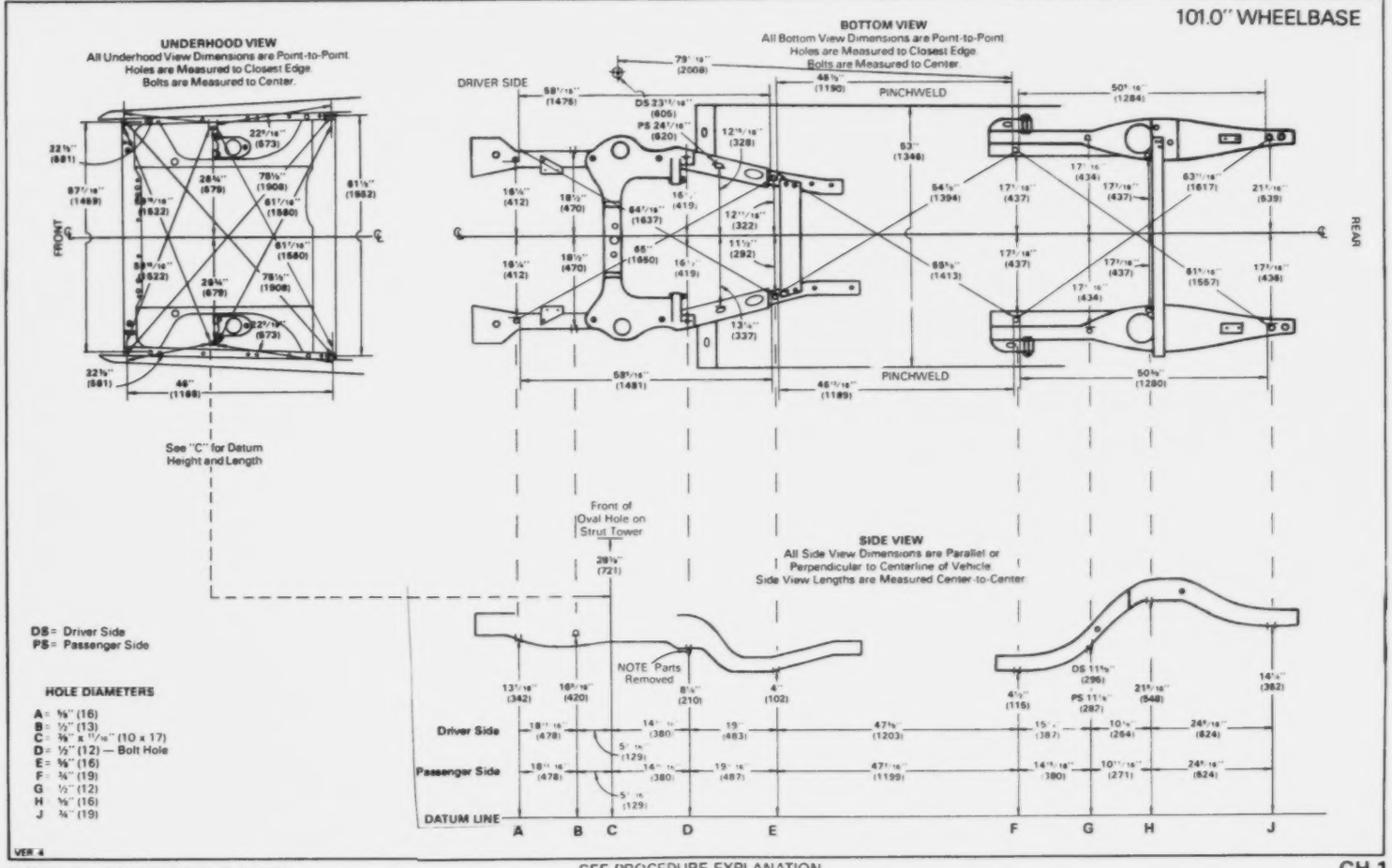
UNIBODY AND CHASSIS DIMENSIONS AND SPECIFICATIONS

CHEVROLET 1986 CAMARO

101.0" WHEELBASE


UNDERHOOD VIEW
All Underhood View Dimensions are Point-to-Point.
Holes are Measured to Closest Edge.
Bolts are Measured to Center.
FRONT
See "C" for Datum Height and Length
BOTTOM VIEW
All Bottom View Dimensions are Point-to-Point.
Holes are Measured to Closest Edge.
Bolts are Measured to Center.
DRIVER SIDE
PINCHWELD
REAR
Front of Oval Hole on Strut Tower
SIDE VIEW
All Side View Dimensions are Parallel or Perpendicular to Centerline of Vehicle.
Side View Lengths are Measured Center-to-Center.
NOTE: Parts Removed
Driver Side
Passenger Side
DATUM LINE
A B C D E F G H J
DS = Driver Side
PS = Passenger Side
HOLE DIAMETERS
A = 5/16" (16)
B = 1/2" (13)
C = 3/8" x 11/16" (10 x 17)
D = 1/2" (12) — Bolt Hole
E = 5/16" (16)
F = 3/4" (19)
G = 1/2" (12)
H = 5/16" (16)
J = 3/4" (19)
VER. 4

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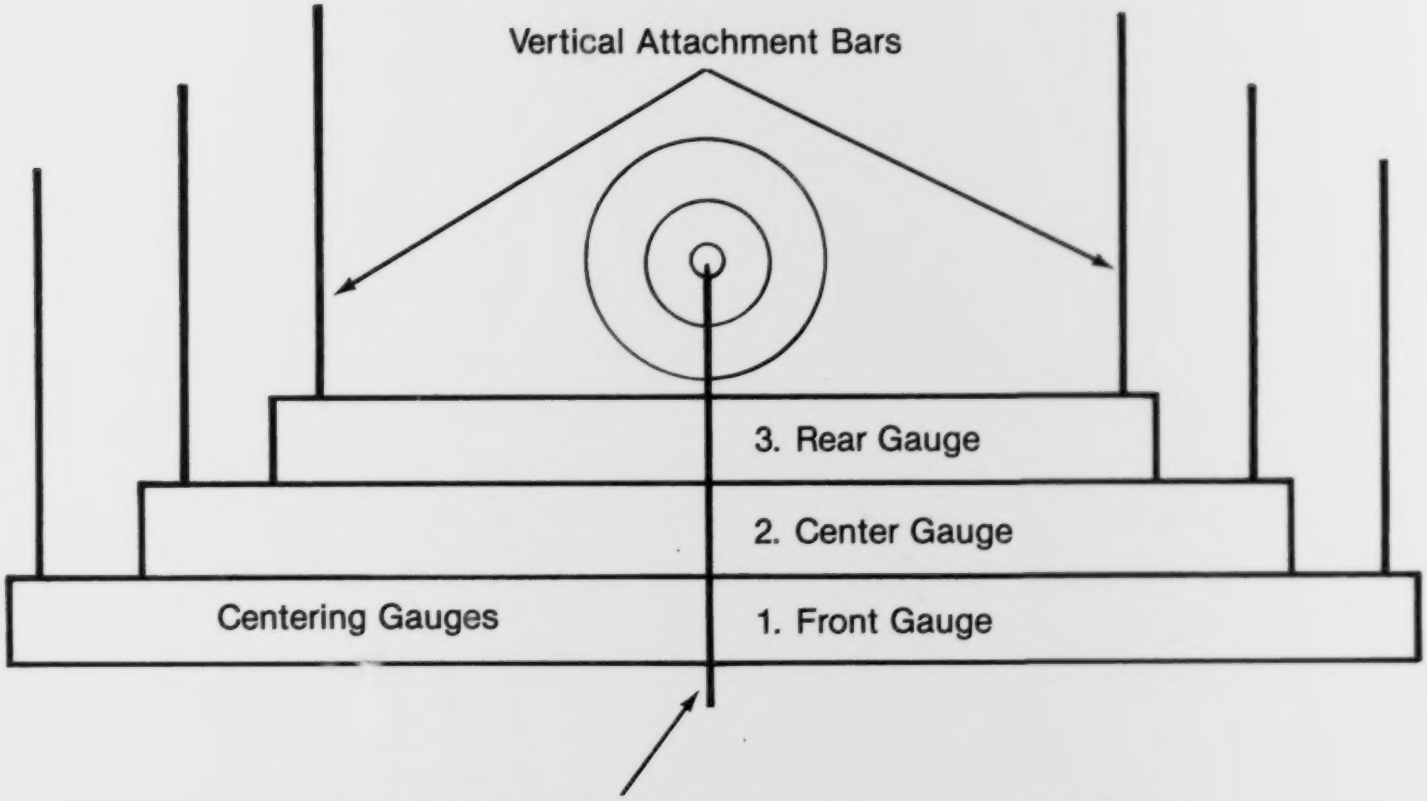
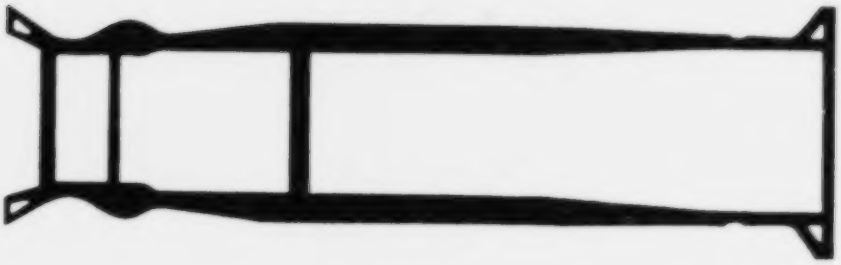
SEE PROCEDURE EXPLANATION

CH-1

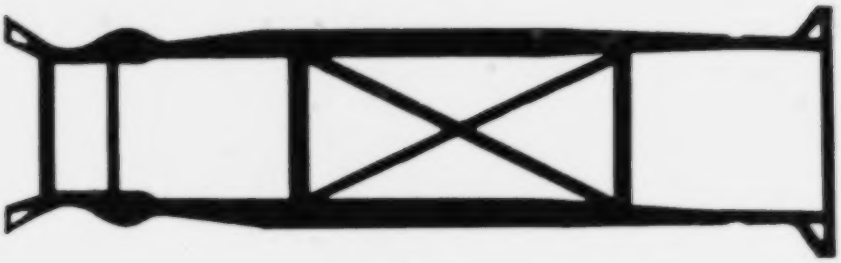
Alignment of a Centering Gauge


Vertical Attachment Bars
3. Rear Gauge
2. Center Gauge
Centering Gauges
1. Front Gauge
Sight pins line up with each other to establish centerline.

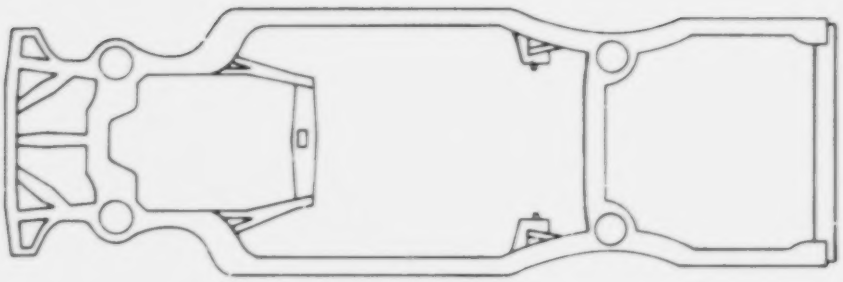
Conventional Frames



Ladder-type

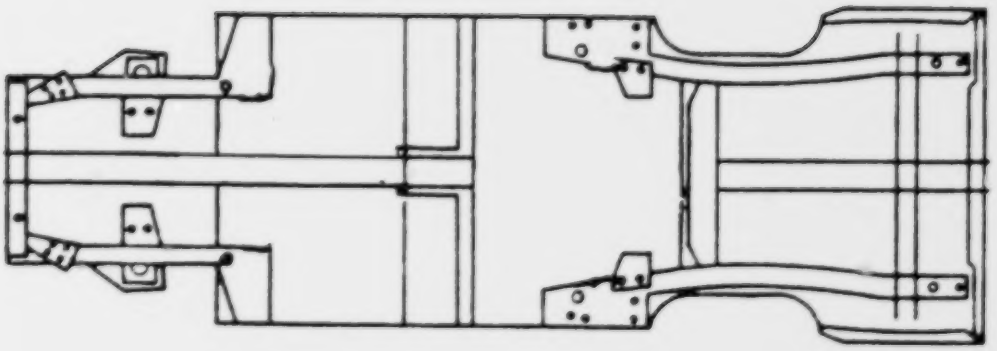


X-type

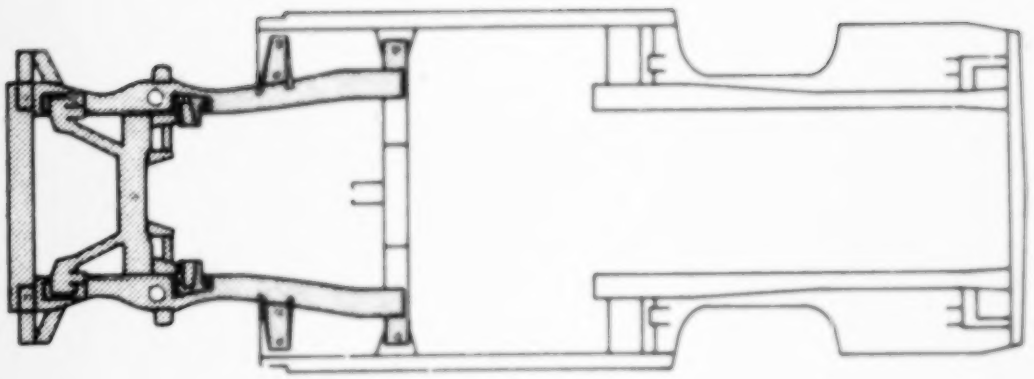


Perimeter

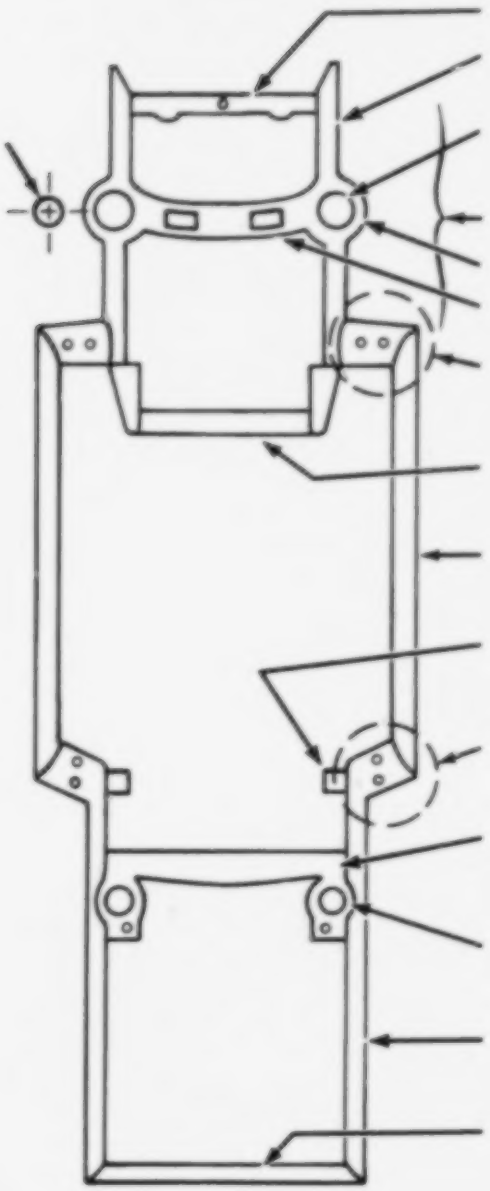
Unitized Body Frame



Combination Frame



Parts of a Perimeter Frame



LOWER
BALL-JOINT
(LOCATION)

FRONT CROSS MEMBER

FRAME HORN

UPPER CONTROL
ARM SHIM
CONTACT POINT

FRONT FRAME RAIL

SPRING POD

MAIN CROSS MEMBER

TORQUE BOX

TRANSMISSION
SUPPORT MEMBER

FRAME SIDE RAIL

STABILIZER MOUNT

TORQUE BOX

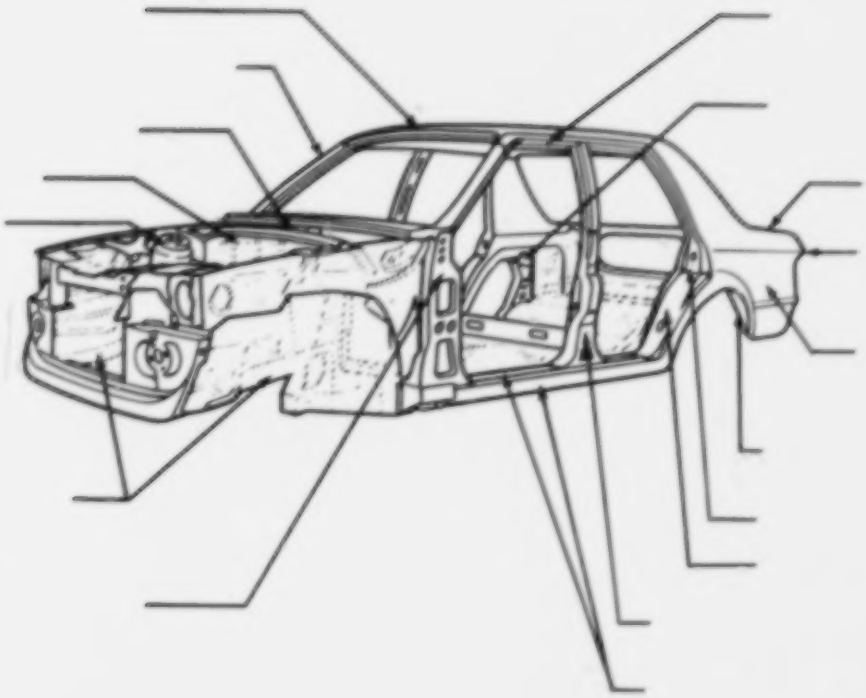
REAR SUSPENSION
CROSS MEMBER

REAR SPRING POD

REAR FRAME STUB

REAR CROSS MEMBER

Parts of a Unitized Body



HEADER BAR

WINDSHIELD PILLAR

COWL TOP PANEL

FIREWALL

STRUT-
TOWER

FRONT RAIL
(INNER & OUTER)

FRONT BODY
HINGE PILLAR

ROOF SIDE RAIL

REAR SHOCK
TOWER

DECK LID

CREASE
OR
BELT LINE

REAR
QUARTER
PANEL

WHEEL HOUSE
(INNER & OUTER)

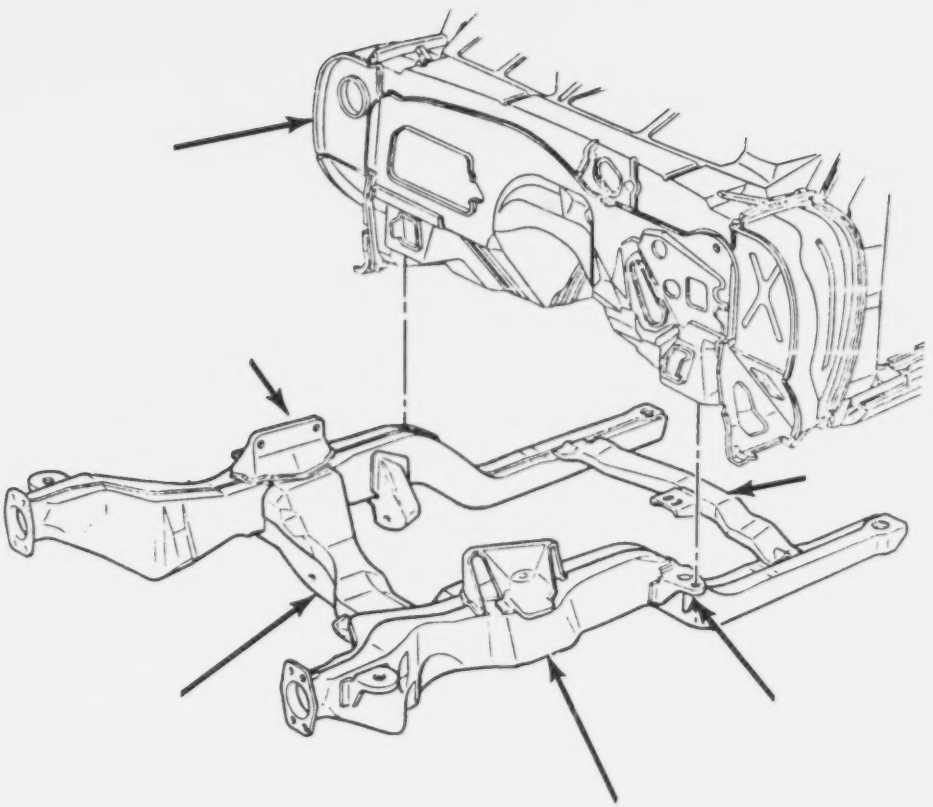
DOG LEG

REAR LOCK PILLAR

CENTER PILLAR POST

ROCKER PANEL
(INNER & OUTER)

Parts of a Combination Frame



Unitized
Body
Section

Stub Frame
Section

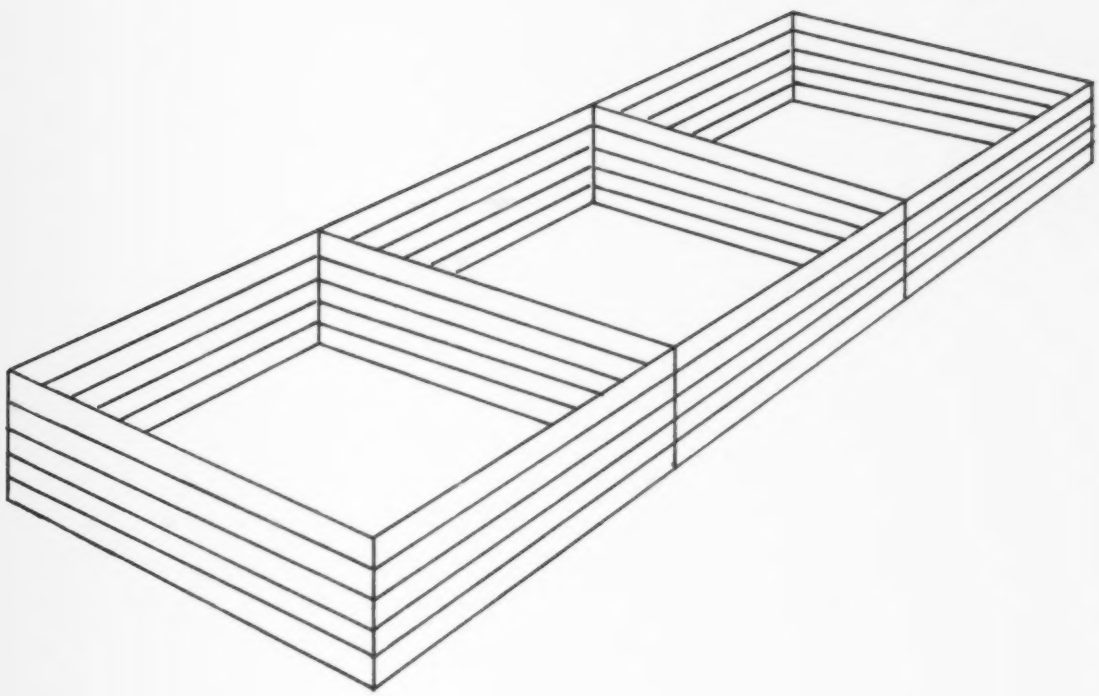
Rear
Cross Member

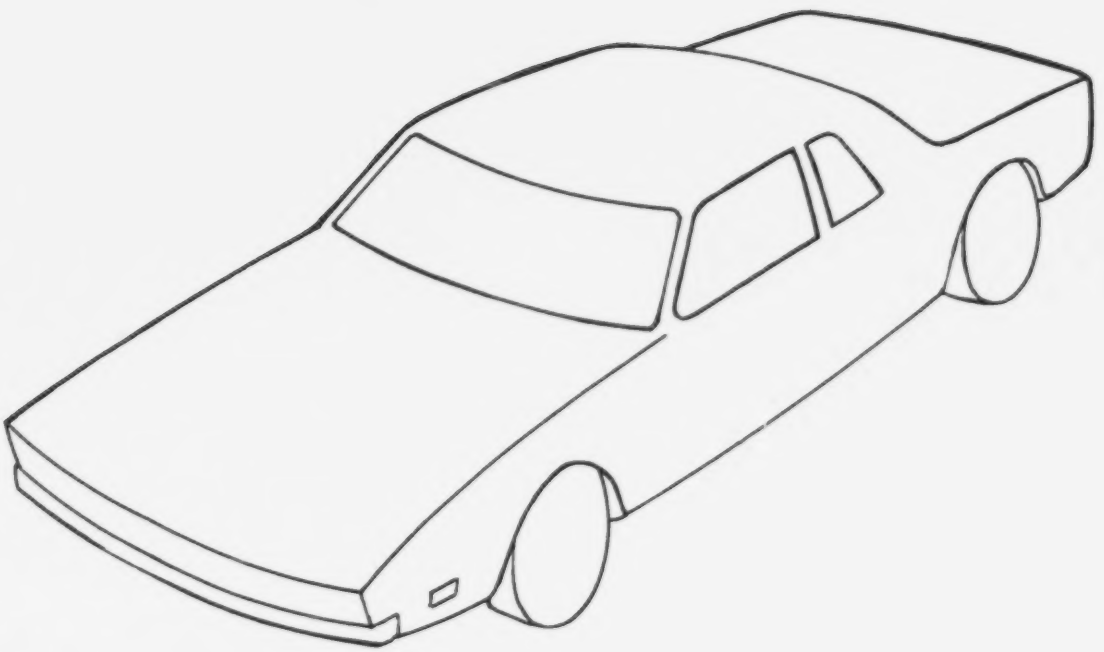
Front Main
Cross Member

Mounting Bracket

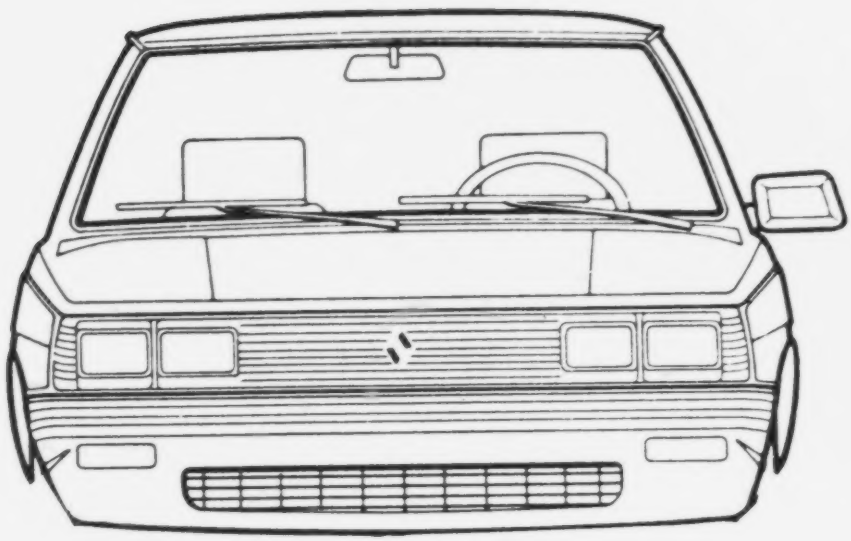
Side Rail

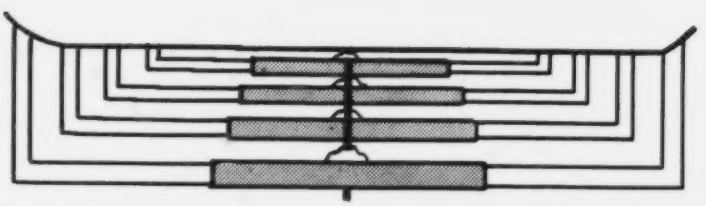
Three-Section Box Representation

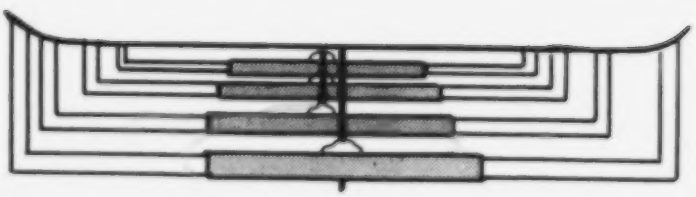


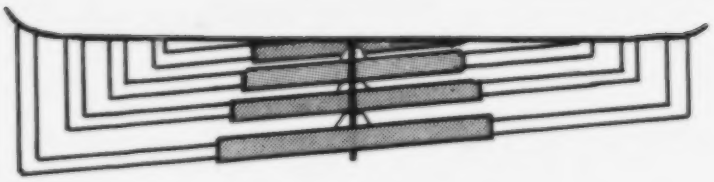


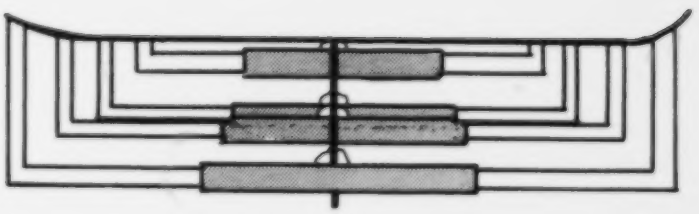
Centering Gauge Alignments

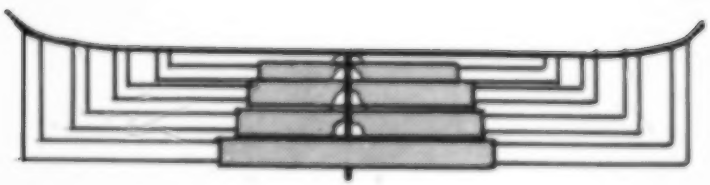


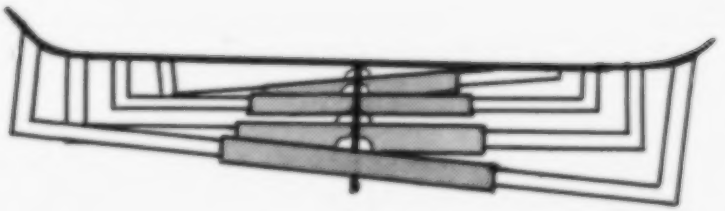












GAUGE AND ANALYZE FRAME DAMAGE
UNIT I

INFORMATION SHEET

I. Terms and definitions

A. Gauge — To use precision measuring tools to determine vehicle dimensions and alignments

B. Alignment — Position of a part of a vehicle in relation to its designed position or to other parts

(NOTE: Parts that are not in their correct position are said to be *misaligned* or to exhibit *misalignment*.)

C. Analyze — To determine the nature and extent of vehicle damage by studying the damage and by comparing the results of gauging the vehicle to its designed dimensions and alignments

D. Frame — Assembly of metal structural parts that supports the vehicle body and drive train and is in turn supported by the wheels

(NOTE: A frame may be a unit separate from the body or it may refer to that part of a unitized body that serves the purpose of a frame.)

E. Unitized body — Vehicle design in which structural support comes from the design and construction of the body instead of from a separate frame

(NOTE: Unitized body construction is also referred to as *unibody* and *unitized body and frame* construction.)

F. Stub frame — Assembly of metal structural parts that supports part of the vehicle body and is attached to another stub frame or to a unitized body

G. Control point — Point on a vehicle frame used as a basis for gauging, analyzing, and repairing damage

H. Frame straightening — Process of returning a damaged vehicle frame to its original shape and alignment

I. Hook up — Method of attaching frame straightening equipment to pull or anchor a vehicle

J. Anchor (tie down) — Method of holding vehicle in place during straightening procedure

K. Pull — Application of a specific amount of force in a particular direction to correct frame damage

INFORMATION SHEET

L. Calibrate — To check or correct the setting of a measuring device or test instrument

M. Graduation — Mark on a measuring device showing the unit of measurement or fractions of the unit of measurement

N. Torque box — Section of frame in some frame designs that twists and turns slightly to absorb shock from vehicle movement or collision

II. Types of frames (Figures 1-5)

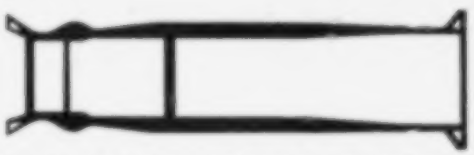
(NOTE: Frame designs are basically one of three types. The conventional frame is a separate unit to which the body is bolted. In unitized bodies, the frame and some body panels are welded together. The third design is a combination of conventional and unitized design where part of the frame is bolted onto a unitized body-frame.)

A. Conventional

(NOTE: Conventional frames were common in earlier cars but are now used almost exclusively for trucks and some large cars.)

1. Ladder-type

FIGURE 1



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2. X-type

FIGURE 2

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3. Perimeter frame

(NOTE: The primary difference between the perimeter frame and other conventional frames is that the side rails of the perimeter frame are aligned with the outside of the passenger compartment and are stepped-in to form the front and rear sections.)

FIGURE 3

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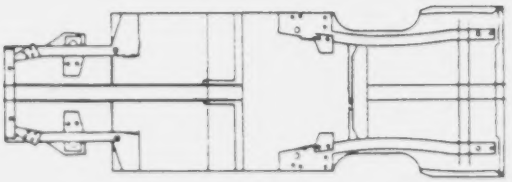
B. Unitized body

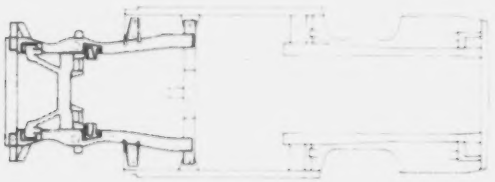
FIGURE 4



C. Combination

(NOTE: The combination frame is often referred to as a *stub frame*.)

FIGURE 5



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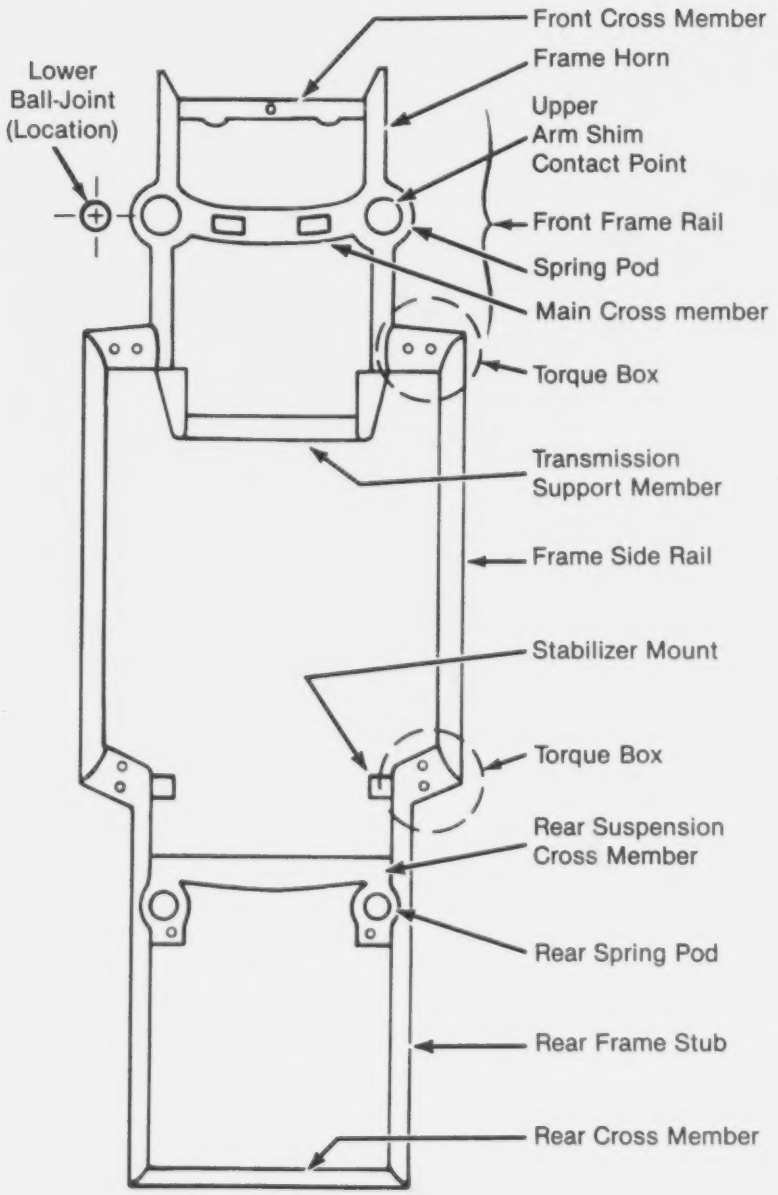
III. Parts of common types of frames (Figures 6-8)

A. Perimeter

FIGURE 6



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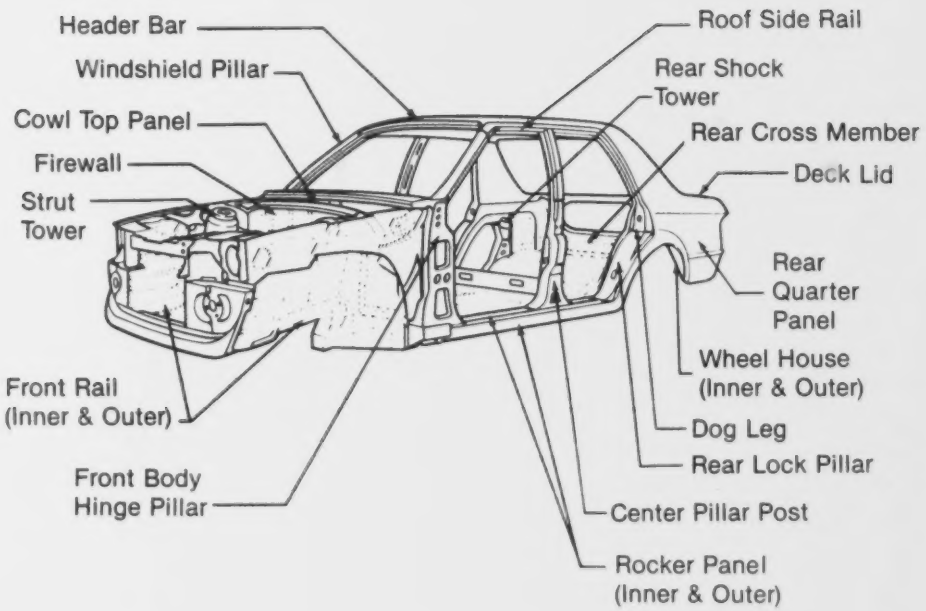
B. Unitized body

FIGURE 7



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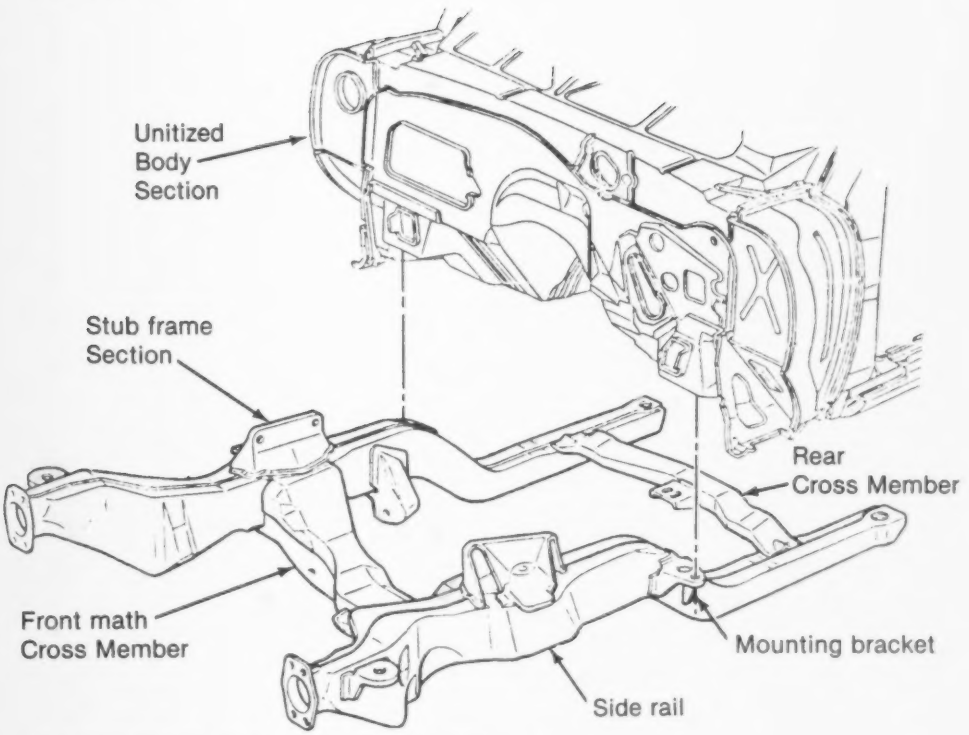
INFORMATION SHEET

C. Combination

FIGURE 8



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IV. Reference elements of damage analysis (Figure 9-12)

(NOTE: Damage analysis is based on the technician's ability to take measurements on the damaged vehicle and to compare them to design dimensions. Design dimensions are given in terms of four reference elements, and may be found in vehicle manufacturer's body service manuals, data sheets published by frame straightener manufacturers, and in specific gauging and analysis guides such as *Tru-Way Car and Truck Frame Manuals* or KLM guides.)

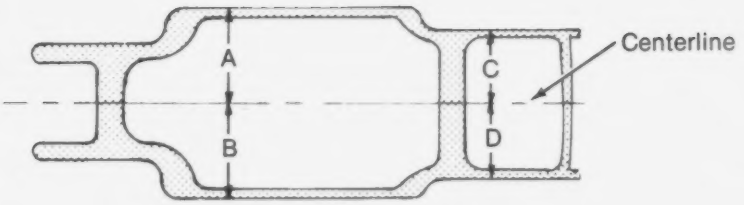
A. Centerline — An imaginary line running the length of the vehicle at an equal distance from each side of frame

(NOTE: There are some vehicles that have an offset "centerline". In these vehicles, dimensions A and B in the figure below would not be the same for all points.)

INFORMATION SHEET

EXAMPLE:

FIGURE 9



A and B are equal distances;

C and D are equal distances.

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B. Level — Condition of corresponding vehicle parts being parallel to each other

(NOTE: Do note think that the term level refers to how the vehicle sits relative to the ground. Level refers to a comparison of one part to a similar part which is designed to be parallel to the first, such as the two side rails of the frame.)

EXAMPLE:

FIGURE 10

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C. Datum — An imaginary line that serves as a base for making measurements at various points on the frame

(NOTE: *Datum* is a drafting term that refers to a line on a blueprint that serves as a reference point for showing measurements. For the auto-body technician, datum lines are shown on frame blueprints in reference manuals and then translated into actual gauge readings.)

EXAMPLE:

FIGURE 11

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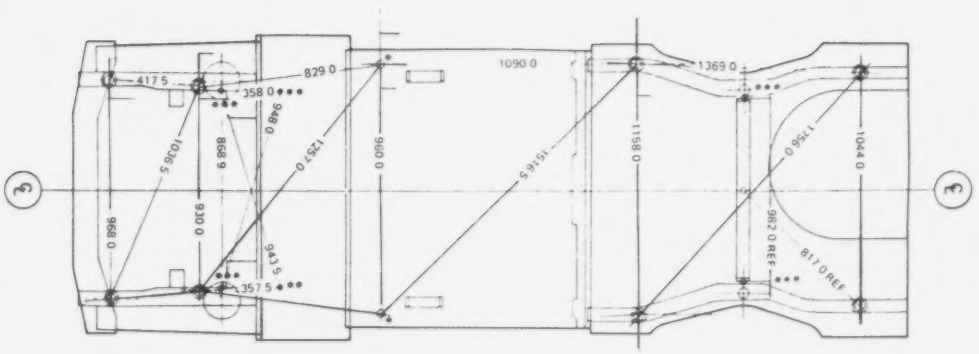
D. Measurements — A comparison of the actual distance between two points on the vehicle and the designed dimensions

(NOTE: Vehicle part alignments must be accurate to within 3 to 5 millimeters or about 1/8 to 3/16 inch. Therefore, it is extremely important that measuring is done precisely.)

EXAMPLE:

FIGURE 12



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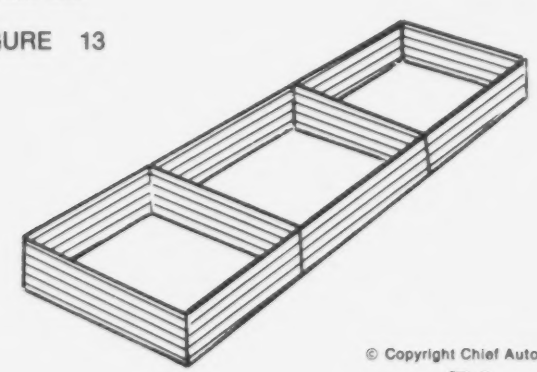
V. Elements of damage analysis as seen in representations of structural damage (Figures 13-22)

(NOTE: The types of damage that occur in the vehicle frame can be pictured fairly easily if you will think of the vehicle in terms of a long box divided into three sections: a front section, a middle section, and a rear section. This representation is shown in Figure 13. The three-section concept is used extensively by such companies as Chief Automotive Systems, and the presentation that follows is based on their materials.)

EXAMPLE:

FIGURE 13



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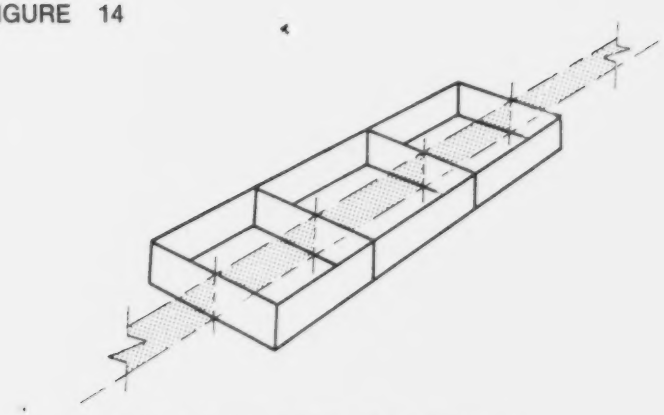
INFORMATION SHEET

A. Centerline

1. Centerline representation

EXAMPLE:

FIGURE 14



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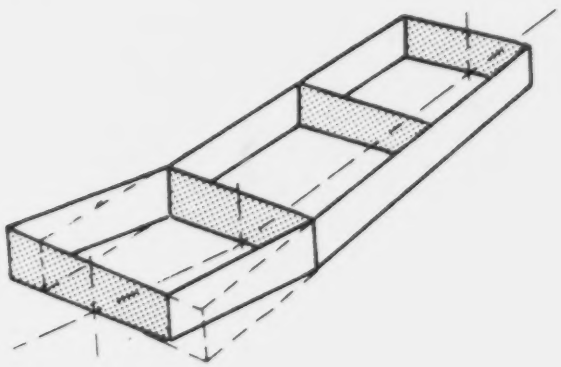
2. Misalignment with respect to centerline

FIGURE 15



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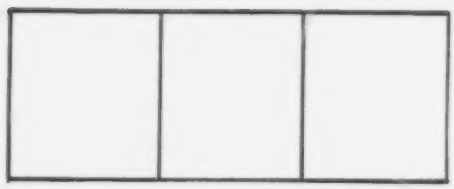
B. Level

1. Level representation

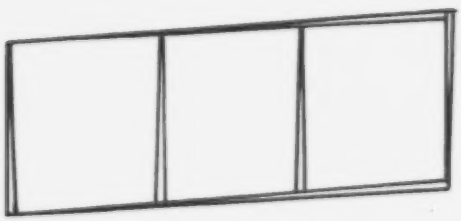
EXAMPLE:

FIGURE 16



2. Misalignment with respect to level

FIGURE 17



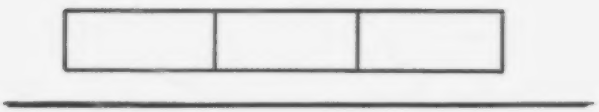
INFORMATION SHEET

C. Datum

1. Datum representation

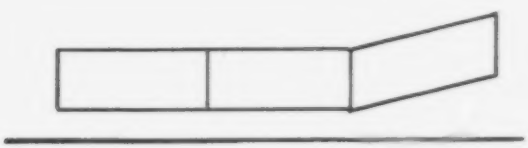
EXAMPLE:

FIGURE 18



2. Misalignment with respect to datum

FIGURE 19



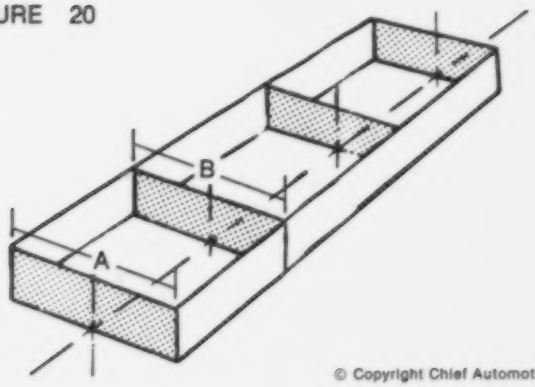
INFORMATION SHEET

D. Measurement

1. Measurement representation

EXAMPLE:

FIGURE 20



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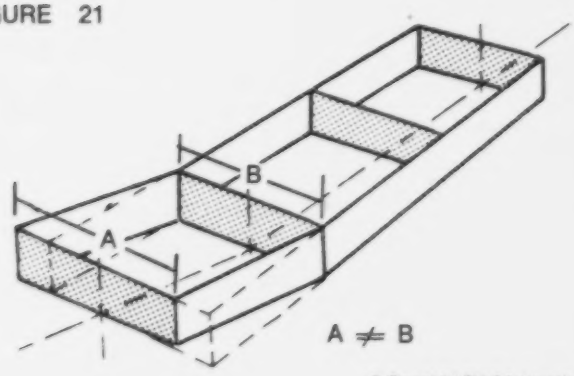
2. Misalignment with respect to measurement

FIGURE 21



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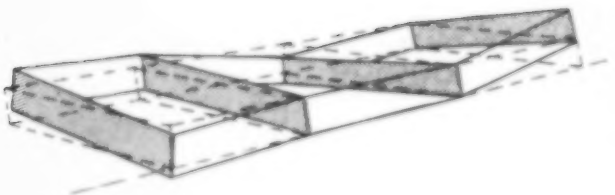
E. Combination

(NOTE: Most frame damage cannot be represented in terms of only one of the elements of damage analysis. In fact, if you study Figure 19, you will see that it represents misalignment with respect to datum as well as with respect to level. Similarly, Figure 21 shows misalignment with respect to centerline as well as with respect to measurement. The fact that most repair jobs involve more than one type of misalignment makes it that much more important for the repair technician to be able to visualize the damage involved.)

INFORMATION SHEET

EXAMPLE:

FIGURE 22



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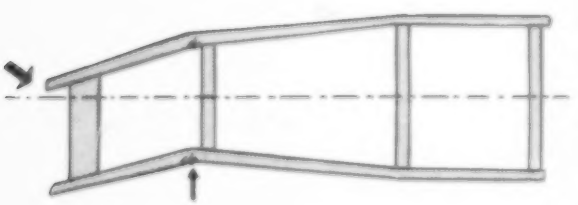
VI. Types of frame and unitized body damage (Figures 23-32)

(NOTE: There are five major types of frame misalignment. These include sidesway, diamond, sag, mash, and twist. Sidesway and diamond are primarily misalignment with respect to the centerline, while sag and mash are misalignments to the datum line. Twist usually involves misalignment to both the centerline and the datum line, and any of the five types may show out-of-level and dimensional misalignment. Additionally, for each of the five types, a full description may also include the location of the damage and some indication of the extent of damage.)

A. Sidesway

1. Sidesway from front-end impact

FIGURE 23



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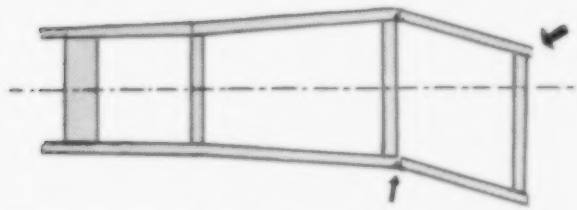
INFORMATION SHEET

2. Sidesway from impact at rear

FIGURE 24



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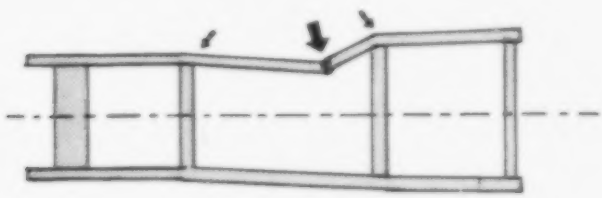
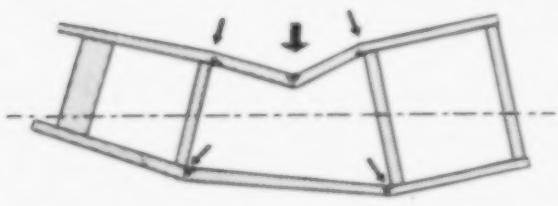
3. Sidesway from impact at center

FIGURE 25



4. Double sidesway from impact at center

FIGURE 26



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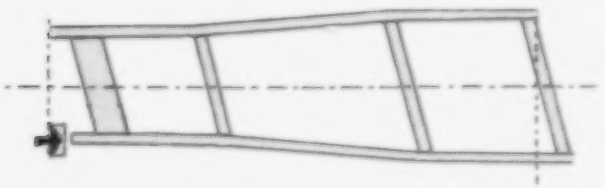
INFORMATION SHEET

B. Diamond

(NOTE: True diamond damage is seldom seen in unitized body construction.)

FIGURE 27



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C. Sag

(NOTE: Sag occurs in the center section, while mash involves the front or rear section.)

1. Sag from front impact

FIGURE 28

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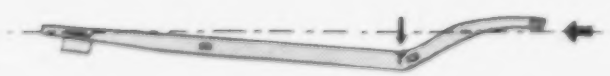
2. Sag from rear impact

FIGURE 29



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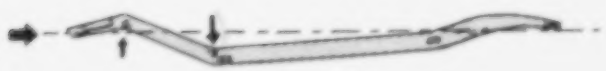
D. Mash

(NOTE: *Mash* is sometimes called *kick-up*, especially if the damage is primarily between the wheels and the end of the vehicle.)

1. Mash from front impact

FIGURE 30



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2. Mash from rear impact

FIGURE 31

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E. Twist

(NOTE: Many technicians believe that twist will occur any time a vehicle has rolled over.)

FIGURE 32

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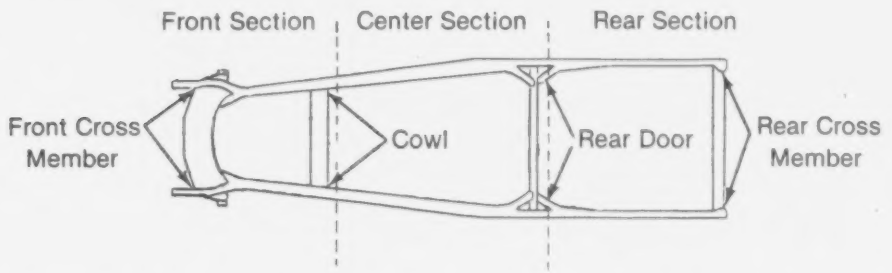
VII. Frame repair control points (Figures 33-35)

(NOTE: Control points are locations on the vehicle frame that are used to gauge damage and to make repairs. They occur at the ends and joints of the three major sections of the frame and are generally the sturdiest areas of the frame. Because the points occur in pairs, the area between the two points is sometimes called a *control area*.)

A. Conventional frame

FIGURE 33



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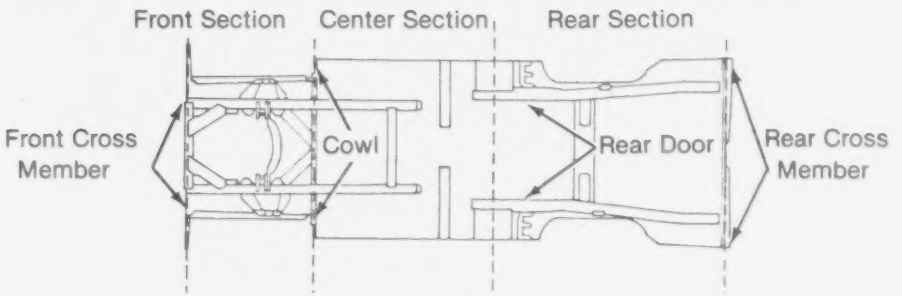
B. Unitized body

FIGURE 34



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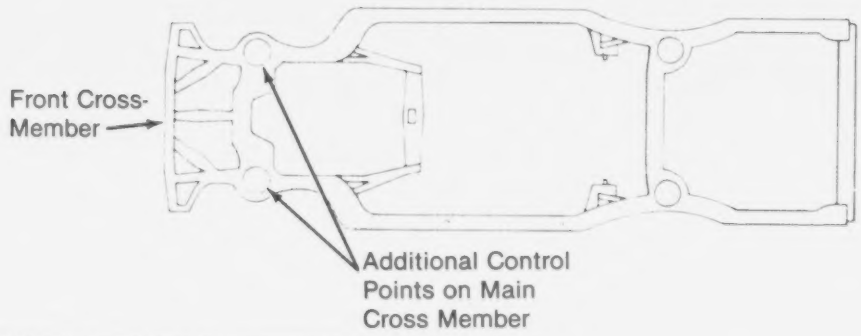
(NOTE: Although there are generally four primary control areas [eight points], the actual control areas will depend on the specific frame design being worked on. Additional control areas may occur anywhere the frame is reinforced, such as at the main front crossmember shown in the frame below.)

EXAMPLE:

FIGURE 35



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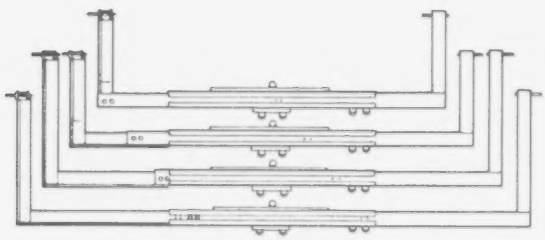
VIII. Equipment used in gauging damage (Figures 36-42)

A. Centering gauge

(NOTE: The centering gauge is generally hung from the frame underneath the vehicle to determine the centerline. The gauge may also be called a *center gauge* or *self-centering gauge*.)

FIGURE 36



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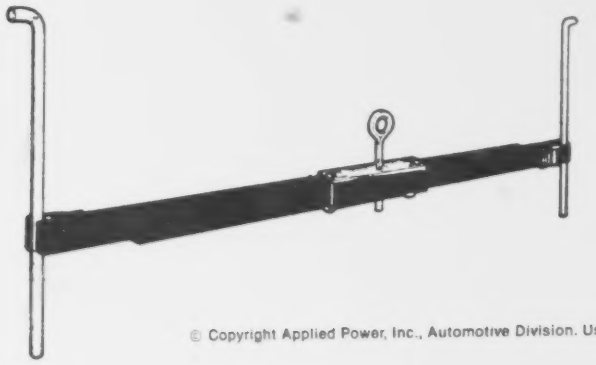
B. Combination centering and datum-line gauge

(NOTE: To determine whether the frame is misaligned with respect to the datum line, a combination centering and datum-line gauge is used or a datum-line attachment is put on a centering gauge.)

FIGURE 37



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C. Tram gauge

(NOTE: The tram gauge is used to measure between two points when an obstacle is in the way, preventing direct measurement. For accurate measurements, the horizontal bar of the tram gauge must be held level. For this reason, some tram gauges are equipped with levels.)

FIGURE 38

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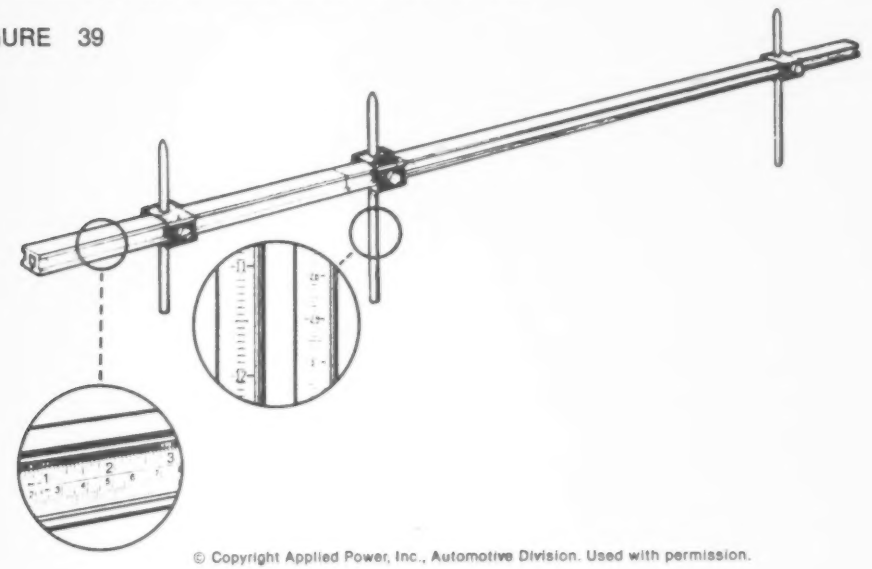
D. Tracking gauge

(NOTE: A tracking gauge is used to determine whether the vehicle's front and rear wheels are correctly aligned with each other. Tracking and the use of the tracking gauge are covered in detail in Unit III.)

FIGURE 39



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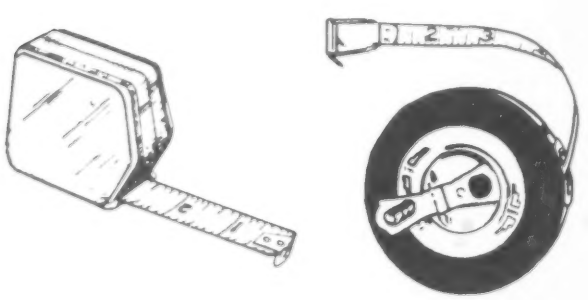
E. Tape measure

(NOTE: Because gauging measurements are given in either standard or metric units, the auto body technician must have both types of tape measures and be able to use them.)

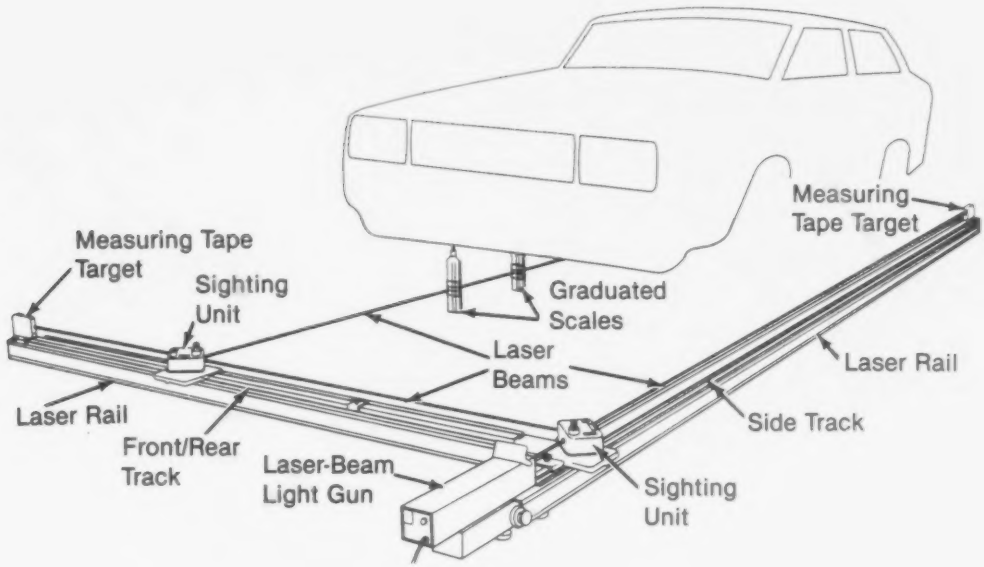
FIGURE 40



INFORMATION SHEET

F. Laser-beam gauging system

FIGURE 41



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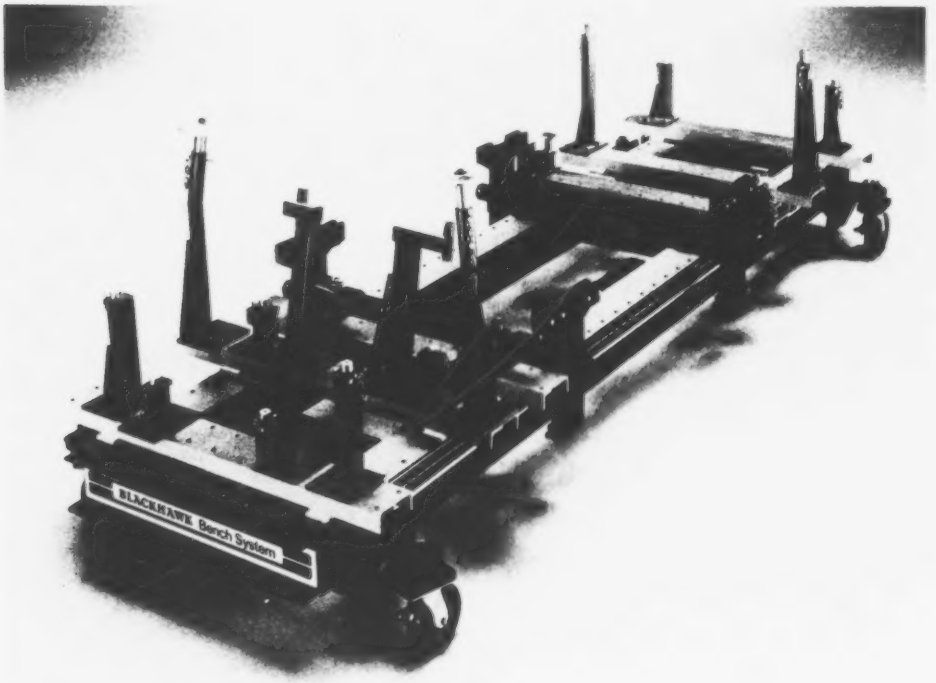
G. Bench

(NOTE: Benches are classed as either *universal* or *dedicated*. A dedicated design used specific fixtures and points for a particular make and model of vehicle, while a universal uses adjustable fixtures.)

FIGURE 42



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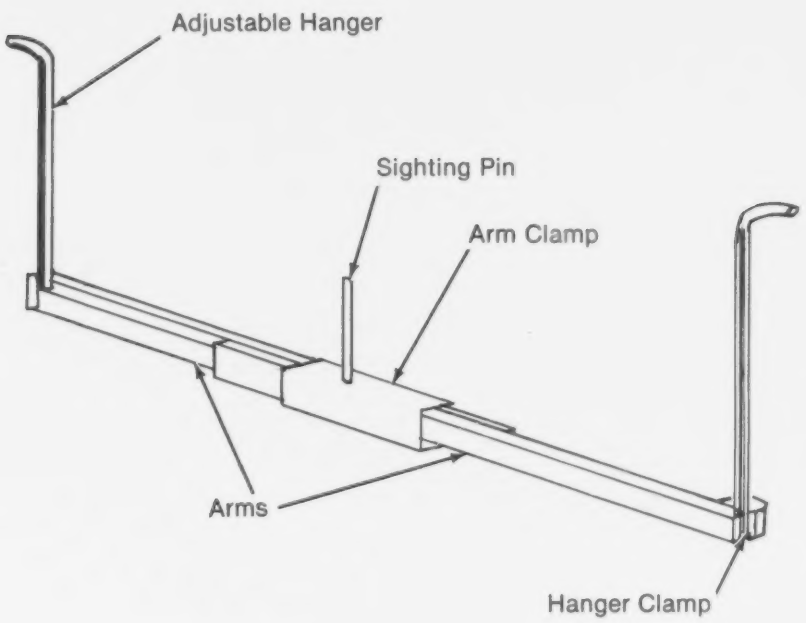
INFORMATION SHEET

IX. Parts of a centering gauge (Figure 43

FIGURE 43

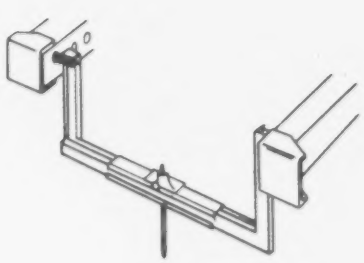


X. Methods of installing centering gauges (Figures 44-49)

A. Mounted in hole

EXAMPLE:

FIGURE 44



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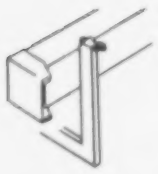
INFORMATION SHEET

B. Resting on top of frame

EXAMPLE:

FIGURE 45



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C. Resting on top of channel

EXAMPLE:

FIGURE 46

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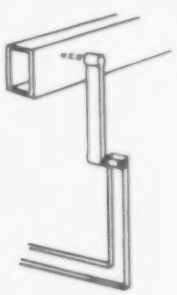
D. Hung with extension

EXAMPLE:

FIGURE 47



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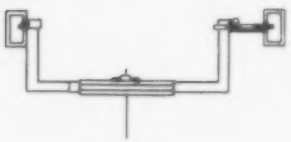
INFORMATION SHEET

E. Hung with offset adapter

EXAMPLE:

FIGURE 48



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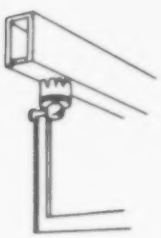
F. Hung with magnetic attachment

EXAMPLE:

FIGURE 49



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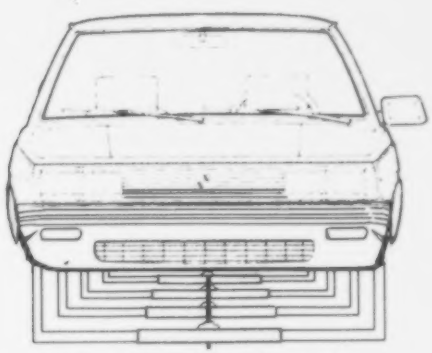
INFORMATION SHEET

XI. Centering gauge alignment for various types of damage (Figures 50-55)

(NOTE: The alignment of centering gauges can tell a technician a great deal about the type of damage that the vehicle has suffered. Centering gauges are normally hung at each control point. In normal, undamaged alignment, the sight pins of the gauges should be aligned with each other and the spacing, both vertically and horizontally, should be proportional as shown in Figure 50.)

EXAMPLE:

FIGURE 50



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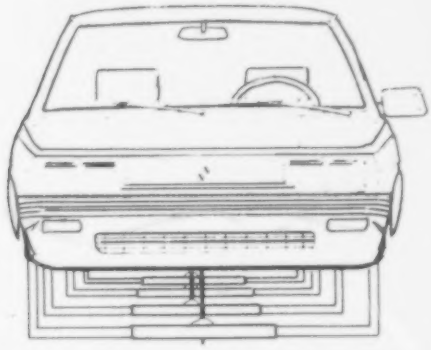
A. Sidesway

(NOTE: Sidesway from a front-end collision is shown.)

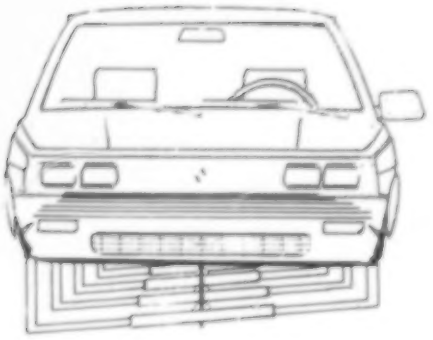
FIGURE 51



INFORMATION SHEET

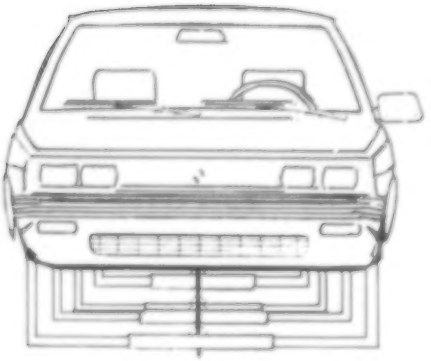
B. Diamond

FIGURE 52



C. Sag

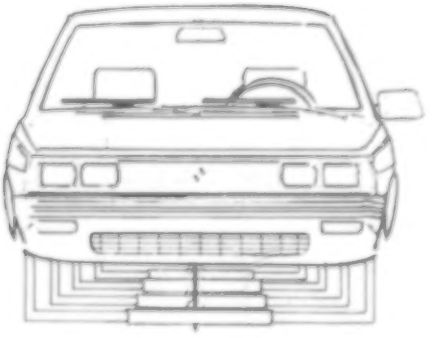
FIGURE 53



D. Mash

(NOTE: Front-end mash is shown.)

FIGURE 54



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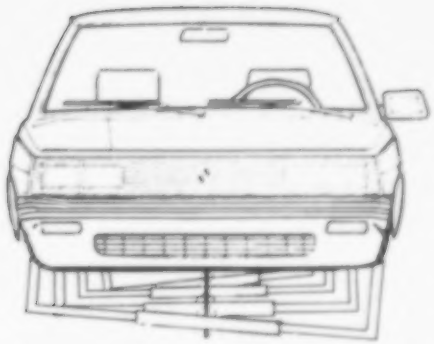
E. Twist

FIGURE 55



XII. Guidelines for installing centering gauges

A. Elevate vehicle and rest on a level surface, with supports adjusted to provide correct datum line

B. Install at least four gauges as near as possible to control points

C. Install enough additional gauges to allow accurate gauging of damage

D. Install ends of gauges at corresponding locations on each side of frame

(NOTE: Extensions or magnets may be necessary at either or both ends to assure that identical locations are used.)

E. Leave gauges in place while repairs are made

(NOTE: When locating gauges, the technician must also keep in mind the location of required repair equipment so that gauges will not interfere with the installation of anchors or pulls.)

F. Keep gauges and attachments clean and calibrated

G. Sight 6 to 8 feet from vehicle, while standing on vehicle centerline

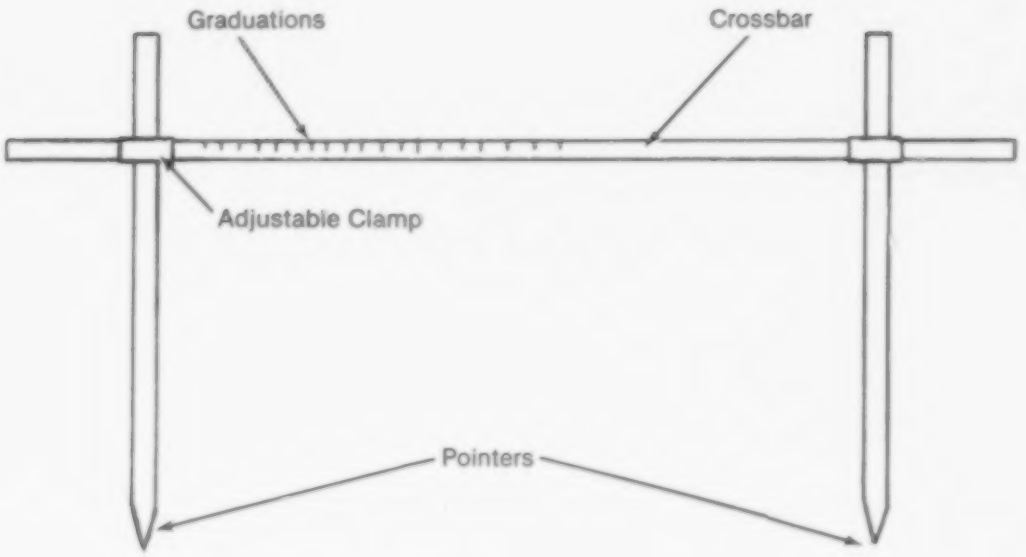
H. Scan ends of crossbars with both eyes open to check for parallel alignment

I. Check sighting pins for alignment by looking down row of pins with one eye closed

INFORMATION SHEET

XIII. Parts of a tram gauge (Figure 56)

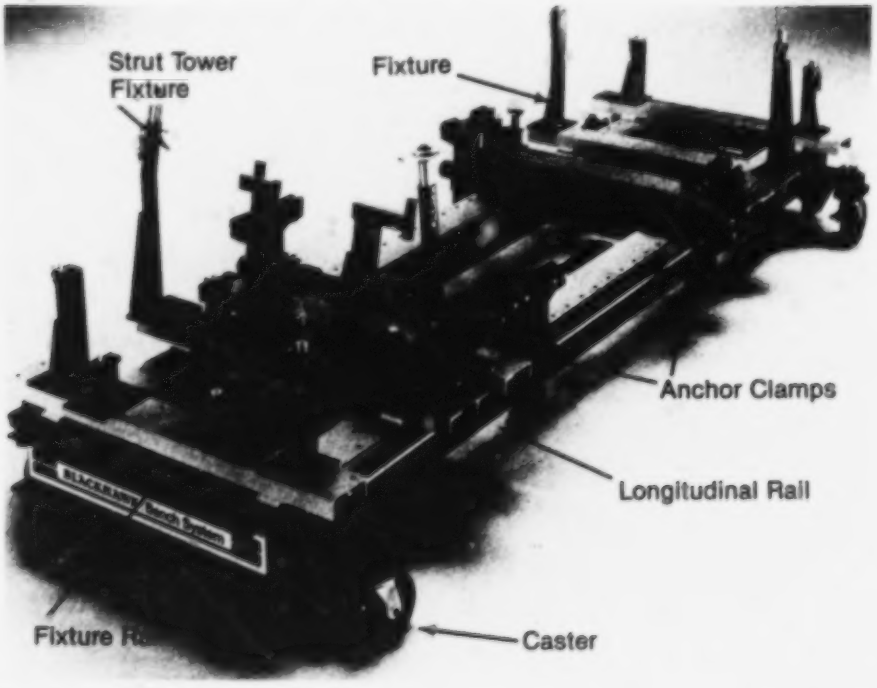
FIGURE 56



INFORMATION SHEET

XIV. Parts of a universal bench (Figure 57)

FIGURE 57



XV. Sequence for gauging damage

(NOTE: Each example of vehicle damage is both unique and similar to other repair jobs. With experience, the technician learns to analyze damage by both sight and gauging tools. From this information, the repair sequence can be planned for the specific job. However, the primary consideration is how misalignment in one section will affect gauging and analyzing other sections. The following sequence will allow a logical approach to gauging and analysis in most cases.)

A. Determine vehicle's three sections

B. Locate control points

C. Remove any parts that will prevent accurate gauging

D. Establish a base by hanging four centering gauges

E. Gauge and correct diamond or twist

F. Gauge and correct centerline misalignment

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G. Gauge and correct level misalignment in center section

H. Gauge and correct datum misalignment in center section

I. Gauge and correct level misalignment in end sections

J. Gauge and correct datum misalignment in end sections

(NOTE: Gauge and correct misalignment in measurements as convenient during repair process. Recheck and adjust gauges as required during repair.)

GAUGE AND ANALYZE FRAME DAMAGE
UNIT I

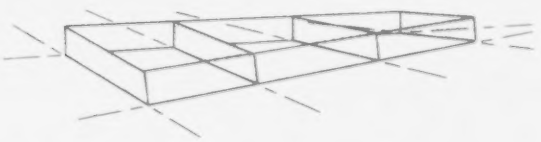
ASSIGNMENT SHEET #1 — ANALYZE BODY-FRAME DAMAGE

NAME _____ SCORE _____

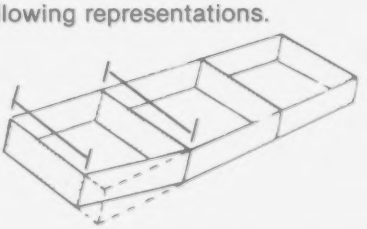
When a vehicle is involved in an accident, it should always be checked for body-frame damage. The severity of the accident will determine the amount and type of damage. Five different types of frame damage can occur, depending on the type of collision: sidesway, sag, mash, diamond, and twist. The vehicle may also be analyzed in terms of the three-box concept explained in Section V of the Information Sheet. Here, alignment may be classified with respect to centerline, level, datum, measurement, or a combination of these aspects.

Study the following representations of body-frame damage and misalignment, and then label each as to the type and location of damage depicted. Remember: Most damage cannot be catagorized in terms of only one or the elements of damage analysis.

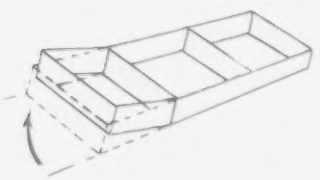
A. Use the three-box concept to analyze damage in the following representations.



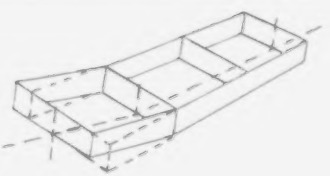
1. _____



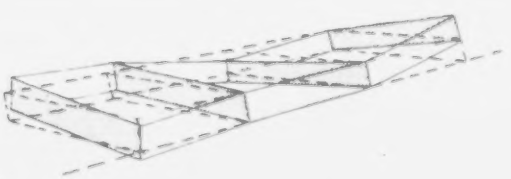
2. _____



3. _____



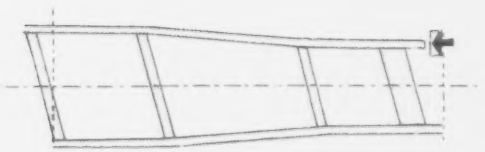
4. _____



5. _____

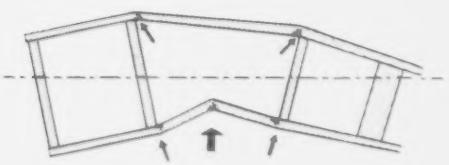
ASSIGNMENT SHEET #1

B. Label the following representations according to the types of frame damage depicted.



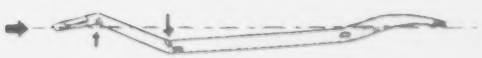
1. _____

2. _____

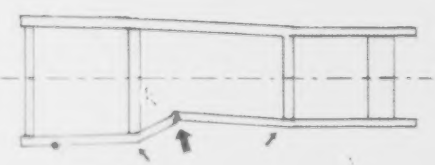


3. _____

4. _____

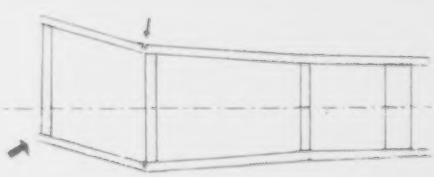


5. _____

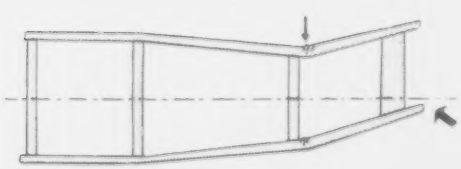


6. _____

7. _____



8. _____



9. _____

10. _____

GAUGE AND ANALYZE FRAME DAMAGE
UNIT I

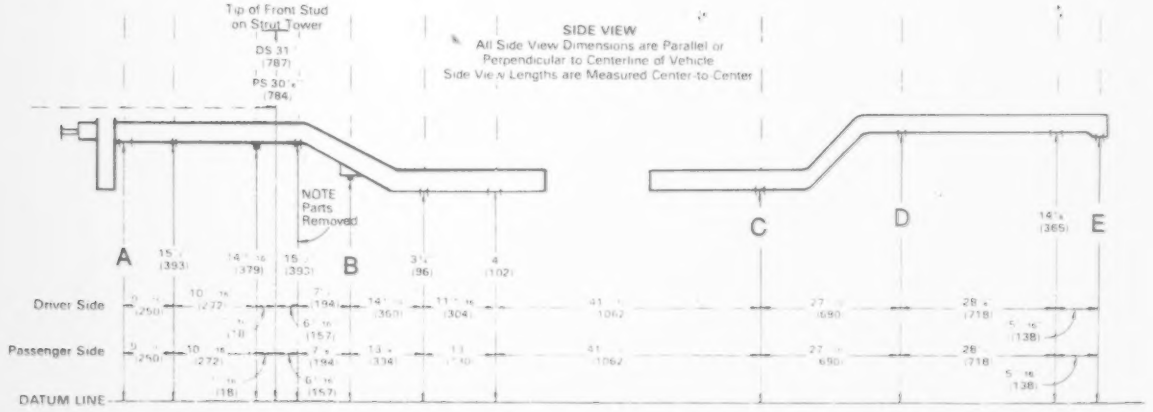
ASSIGNMENT SHEET #2 — USE SPECIFICATION GUIDES TO DETERMINE GAUGING DIMENSIONS

NAME _____ SCORE _____

Today's vehicles are designed with very close tolerances in their construction dimensions. In making repairs, the technician must return the vehicle to its original dimensions using those same tolerances. Because of this, technicians must be able to determine the required dimensions, and this is often done using specifications guides. Accurate gauging, and thus accurate repairs, are only possible if the technician is able to use such specification guides correctly.

In this assignment sheet, you will find several drawings from specification guides for various makes and models of vehicles. Use specification guides to determine missing dimensions in the drawings and to answer questions accompanying the drawings.

A. 1984 Ford Thunderbird



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1. What are the dimensions at the following locations?

   a. _____ d. _____

   b. _____ e. _____

   c. _____

2. What are the least and the greatest dimensions for the front stud of the strut tower?

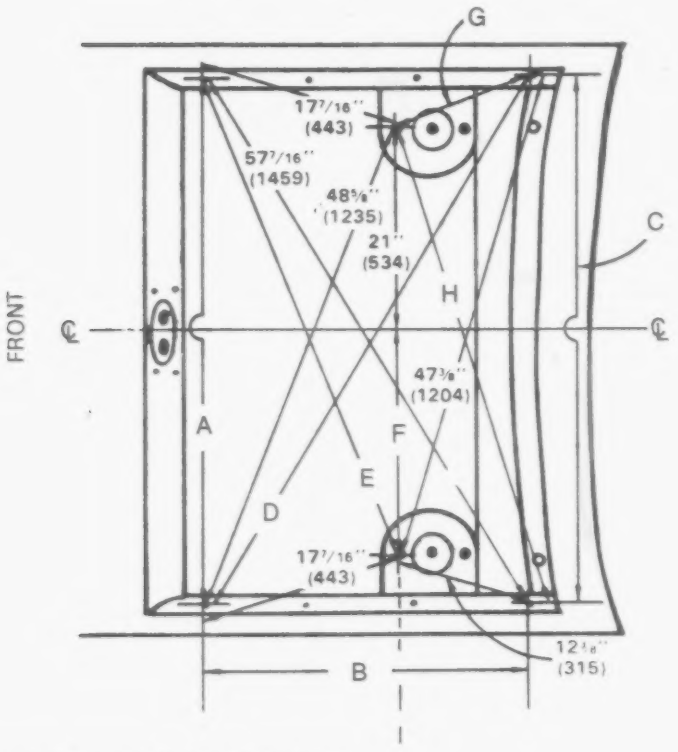
   a. Least — _____

   b. Greatest — _____

ASSIGNMENT SHEET #2

B. 1983 Volkswagen Rabbit engine compartment

UNDERHOOD VIEW
All Underhood View Dimensions are Point-to-Point.
Holes are Measured to Closest Edge.
Bolts and Studs are Measured to Center.



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1. What are the dimensions shown?

   a. _____ e. _____

   b. _____ f. _____

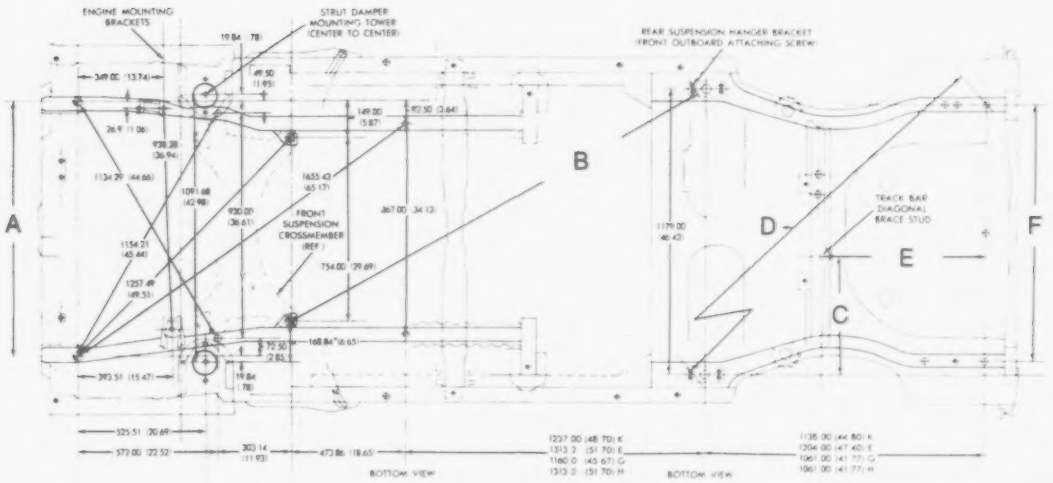
   c. _____ g. _____

   d. _____ h. _____

2. Dimension g is the distance from the _____ to the _____

ASSIGNMENT SHEET #2

C. 1986 Chrysler front-wheel drive, body codes E, K, G, H



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1. What are the dimensions shown?

   a. E—_____

   b. E—_____

   c. K—_____

   d. K—_____

   e. G—_____

   f. H—_____

2. Which vehicle has the longest rear section (from the rear suspension hanger bracket to the rear gauging hole)?

   _____

3. Give one example of each type of vehicle.

   a. E—_____

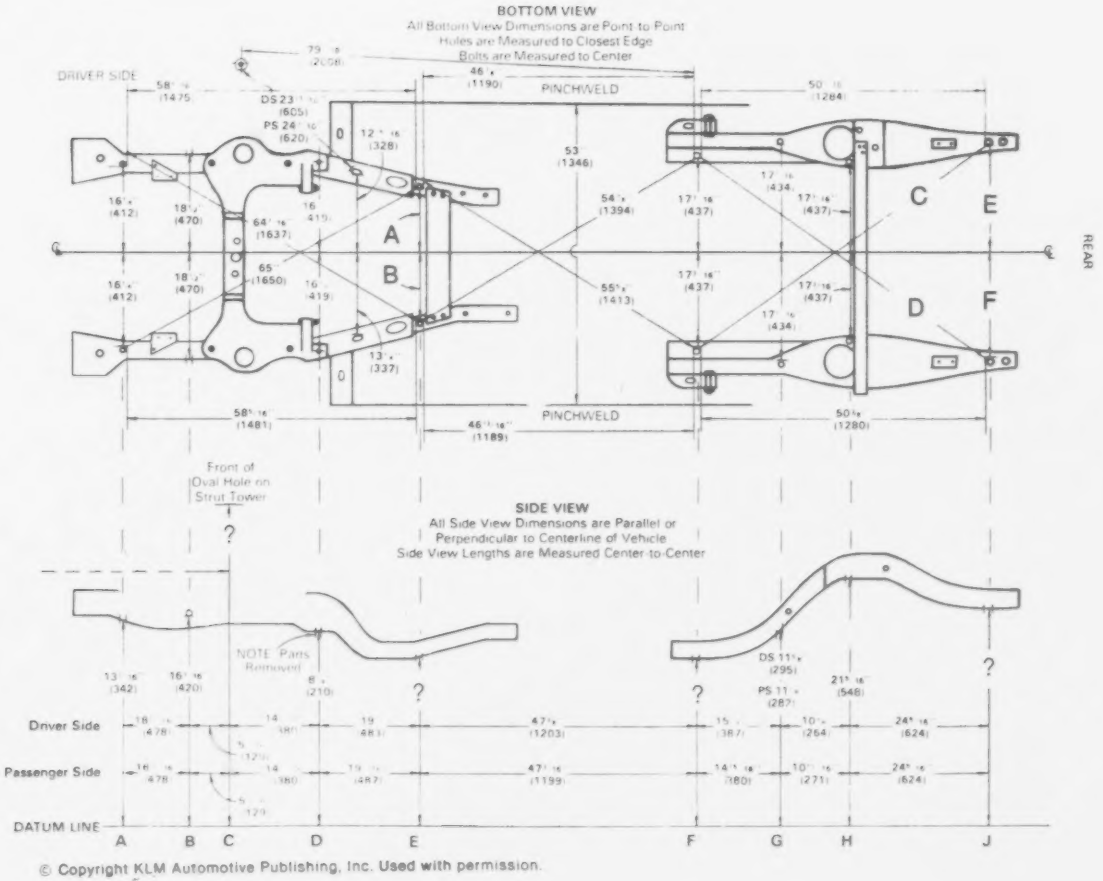
   b. K—_____

   c. G—_____

   d. H—_____

ASSIGNMENT SHEET #2

D. 1986 Camaro



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1. What are the dimensions shown?

   a. _____ d. _____

   b. _____ e. _____

   c. _____ f. _____

2. What is the datum line setting for centering gauges installed at the control points?

   a. Front strut tower — _____

   b. Cowl area — _____

   c. Rear door area — _____

   d. Rear gauging hole — _____

GAUGE AND ANALYZE FRAME DAMAGE
UNIT I

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

A. 1. Misalignment with respect to level
2. Misalignment with respect to measure; misalignment with respect to centerline
3. Misalignment with respect to datum; misalignment with respect to level
4. Misalignment with respect to level
5. Combination

B. 1. Diamond
2. Twist
3. Double sidesway from impact at center
4. Mash from rear impact
5. Mash from front impact
6. Sidesway from impact at center
7. Sag from rear impact
8. Sidesway from impact at rear
9. Sidesway from front-end collision
10. Sag from front impact

Assignment Sheet #2

(NOTE: Answers may vary due to differences in references used. The answers given below are correct for the references included in the instructor's supplements.)

A. 1. a. 15 1/2", 393 mm
b. 6 3/4", 171 mm
c. 4 1/16", 104 mm
d. 15", 381 mm
e. 13 7/16", 342 mm

2. a. 30 7/8", 784 mm
b. 31", 787 mm

B. 1. a. 49 1/4", 1251 mm
b. 28 7/8", 733 mm
c. 50 1/16", 1271 mm
d. 57 7/16", 1459 mm
e. 48 5/8", 1235 mm
f. 21", 534 mm
g. 12 3/8", 315 mm
h. 47 3/8", 1204 mm

2. Front stud of strut tower to rear bolt of fender

ANSWERS TO ASSIGNMENT SHEETS

C. 1. a. 1052 mm, 41.42″
b. 1986.55 mm, 78.21″
c. 489.5 mm, 19.27″
d. 1628.4 mm, 64.11″
e. 578.2 mm, 22.76″
f. 1055.05 mm, 41.54″

2. E

3. (Answer should include one of the following for each item)

a. Plymouth Caravelle, Dodge 600, Chrysler New Yorker
b. Plymouth Reliant, Dodge Aries or 600, Chrysler LeBaron, Town and Country, or Limousine
c. Dodge Daytona, Chrysler Laser
d. Dodge Lancer, Chrysler LeBaron GTS

D. 1. a. 12 11/16″, 322 mm
b. 11 1/2″, 292 mm
c. 63 11/16″, 1617 mm
d. 61 5/16″, 1557 mm
e. 21 3/16″, 539 mm
f. 17 3/16″, 436 mm

2. a. 28 3/8″, 721 mm
b. 4″, 102 mm
c. 4 1/2″, 115 mm
d. 14 1/4″, 362 mm

GAUGE AND ANALYZE FRAME DAMAGE
UNIT I

JOB SHEET #1 — CLEAN AND CALIBRATE CENTERING GAUGE

I. Equipment and materials

A. Centering gauge

B. Steel square

C. Open-end wrenches

D. Clean cloths

E. Cleaning solvent

F. Rubber gloves

G. Fine-grit sandpaper

II. Procedure

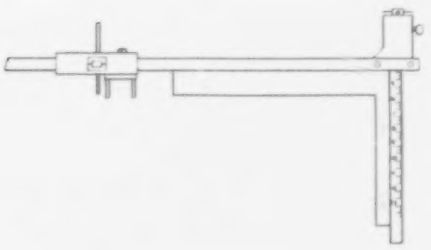
A. Clean centering gauge

1. Read all instructions and cautions on cleaning solvent
2. Put on rubber gloves
3. Wipe surfaces of gauges with cleaning solvent
4. Wipe excess solvent from surfaces with dry cloth
5. Reposition moving parts, and repeat steps 3 and 4 to clean entire gauge
6. If buildup is excessive, rub required areas lightly with fine-grit sandpaper and then clean with solvent

B. Calibrate centering gauge

1. Place steel square along arm and adjustable hanger (Figure 58)

FIGURE 58



2. Check for square fit

3. Adjust as necessary

   (NOTE: The exact adjustment procedure varies with manufacturers. Check the manufacturer's instructions if available.)

   a. Loosen attaching bolts on clamp

   b. Reposition clamp until hanger and arm are square

   c. Tighten attaching bolts

C. Clean work area and return equipment and materials to proper storage

GAUGE AND ANALYZE FRAME DAMAGE
UNIT I

JOB SHEET #2 — PREPARE VEHICLE FOR GAUGING AND ANALYSIS

I. Equipment and materials

- A. Centering gauges
- B. Tram gauges
- C. Steel tape
- D. Vehicle
- E. Specification guide for vehicle
- F. Supports required for vehicle

II. Procedure

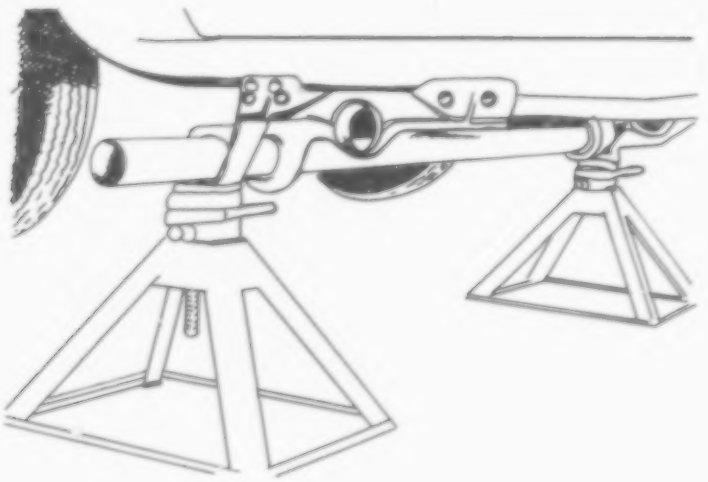
- A. Place vehicle on flat, level surface
- B. Determine minimum clearance between vehicle and datum line
- C. Raise vehicle and place on jack stands

  (NOTE: Follow the vehicle manufacturer's recommendations for raising and supporting the vehicle.)

  1. Raise vehicle high enough so that the final supported clearance allows enough room for centering gauges to be hung easily at datum line
  2. For conventional frames, place jack stands at or near each torque box or at the corners of center section as recommended by manufacturer
  3. For unibody designs, install clamps on pinch welds and place vehicle on support tubes (Figure 59)

JOB SHEET #2

FIGURE 59



D. Determine control points

E. Remove any damaged parts that will interfere with installation of gauges

F. Determine methods of installing centering gauge for each control point

G. Clean and calibrate centering gauges, if necessary (Job Sheet #1)

H. Install centering gauge at each control point so that it will not interfere with anchoring and pulling attachments

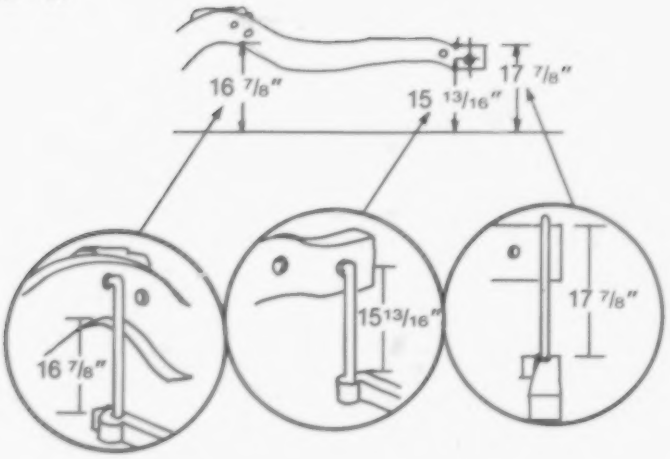
I. Adjust centering gauges to datum line

1. Determine datum line distance for each gauge

(NOTE: The distance is that shown in the reference guide between the datum line and the attachment point of the centering gauge. See example in Figure 60.)

JOB SHEET #2

FIGURE 60



2. Adjust one end of gauge so that top of crossbar is at datum distance
3. Adjust opposite end of gauge so that top of crossbar is at datum distance
4. Check for correct distance at end adjusted first and repeat steps 2 and 3 until each end is at correct distance
5. Adjust each end of remaining gauges
6. Check gauges for correct distance and tighten adjusting clamps securely

J. Center sighting pin on each gauge

K. Gauge and analyze damage, using correct sequence for specific type of damage present (See Job Sheets #4 - #9.)

GAUGE AND ANALYZE FRAME DAMAGE
UNIT I

JOB SHEET #3 — POSITION VEHICLE ON BENCH

I. Equipment and materials

A. Vehicle

B. Specification guide for vehicle

C. Bench and accessories

D. Instruction manual for bench

II. Procedure

(NOTE: Your instructor will demonstrate the type of bench used in your shop.)

GAUGE AND ANALYZE FRAME DAMAGE
UNIT I

JOB SHEET #4 — GAUGE AND ANALYZE DIAMOND

I. Equipment and materials

A. Centering gauges

B. Diamond detector attachment

C. Tram gauges

D. Steel tape

E. Vehicle with diamond damage or simulator

F. Specification guide for vehicle

G. Plumb bob

H. Chalk

I. Supports required for vehicle

II. Procedure

(NOTE: Three methods for checking for diamond damage are described in this job sheet. The method used depends on the vehicle, the gauging conditions, and the technician's preference. The student should practice all three methods.)

A. Visually inspect vehicle for signs of diamond

EXAMPLES:
1. Hood and trunk lid misaligned
2. Buckles in the quarter panels
3. Buckles near rear wheel
4. Buckles at joints between quarter panels and roof
5. Buckles in floor and misalignment of doors in unitized bodies

(NOTE: Diamond damage is easily hidden by other types of damage, so the center section is used as the surest indicator of diamond damage. Remember that diamond damage is rare in unibody construction.)

B. Perform preliminary check, using chalk and plumb bob

(NOTE: This method provides a quick check for diamond damage and is convenient if the vehicle is still driveable.)

1. Park vehicle on a flat, level surface

2. Determine control points at each corner of center section

   (NOTE: Avoid using torque boxes on vehicles that are so equipped because these may be distorted. Also, on trucks and pickups, use points under the cab section because points farther back on the frame may be distorted by rear sway.)

3. Hang plumb bob from one control point, and mark floor with chalk at the plumb bob point

4. Repeat Step 3 at other control points

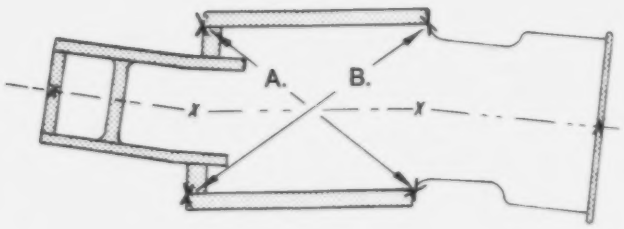
5. Move vehicle from area

6. Measure diagonally between two control points; measure diagonally between the other two control points

7. Compare the two diagonal readings

   (NOTE: If one diagonal measurement is longer than the other, diamond damage is present. See Figure 61.)

FIGURE 61



C. Prepare vehicle for gauging and analysis

D. Check alignment of centering gauges

   (NOTE: Diamond damage is seen in the centering gauges when the gauges do not hang square to the side rails.)

E. Check for diamond damage using tram gauges

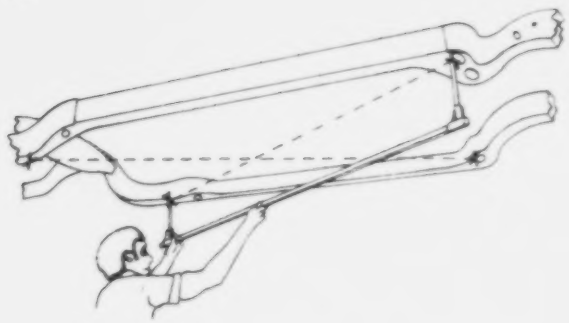
   1. Determine control points at each corner of center section

      (NOTE: Avoid using torque boxes on vehicles that are so equipped as these may be distorted. Also, on trucks and pickups, use points under the cab section because points farther back may be distorted by rear sway.)

JOB SHEET #4

2. Align points on tram gauge with two points diagonally opposite each other (Figure 62)

FIGURE 62

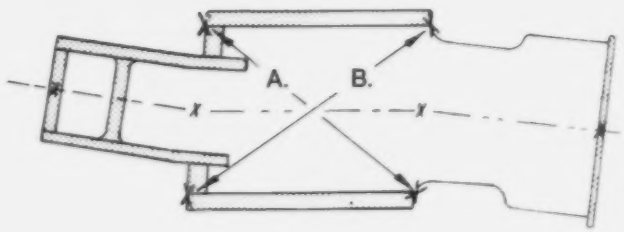


3. Gauge distance between other two control points

4. Compare the two diagonal readings

(NOTE: If one diagonal measurement is longer than the other, diamond damage is present. See Figure 63.)

FIGURE 63



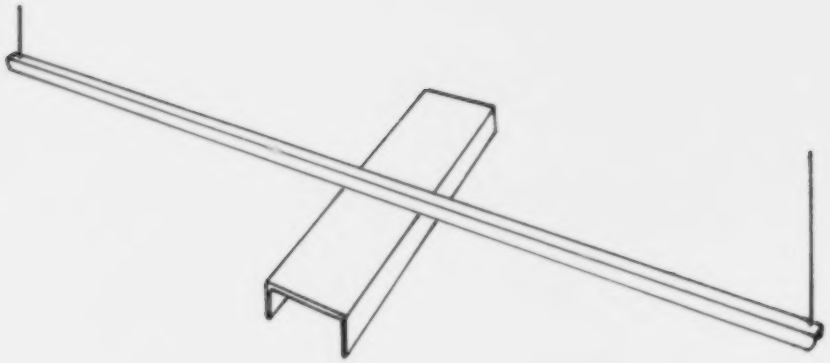
B is longer than A

F. Check for diamond damage using diamond-detector attachment

1. Place diamond-detector attachment on center section centering gauges following detector manufacturer's recommendations (See Figure 64.)

JOB SHEET #4

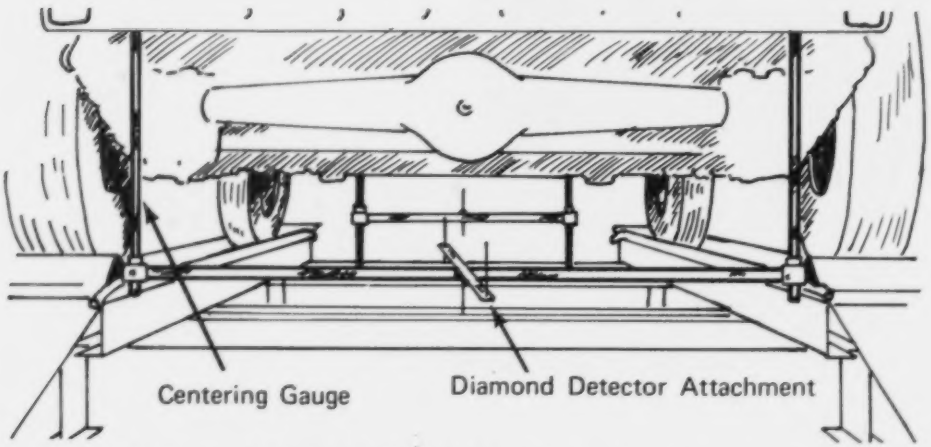
FIGURE 64



2. Sight along centering gauge sighting pins and diamond-detector attachment sighting pins

   (NOTE: If the sighting pins on the attachment are not aligned with the sighting pins of the center section centering gauge, diamond damage is present. See Figure 65.)

FIGURE 65



G. Repair diamond damage before continuing to gauge other types of damage

   (NOTE: Repair procedures are covered in Unit II.)

H. Clean work area and return equipment and materials to proper storage

GAUGE AND ANALYZE FRAME DAMAGE
UNIT I

JOB SHEET #5 — GAUGE AND ANALYZE TWIST

I. Equipment and materials

A. Centering gauges

B. Tram gauges

C. Steel tape

D. Vehicle with twist damage or simulator

E. Specification guide for vehicle

F. Supports required for vehicle

II. Procedure

A. Visually inspect vehicle for signs of twist damage

EXAMPLES:
1. One corner or opposite corners of vehicle uneven with corner on same side
2. Wheels not centered in wheel wells when viewed from side
3. Ends of vehicle tilted to one side with no apparent mash or sidesway
4. Misalignment of doors with no apparent related frame or body damage
5. Cracked or broken front or rear glass with no apparent impact

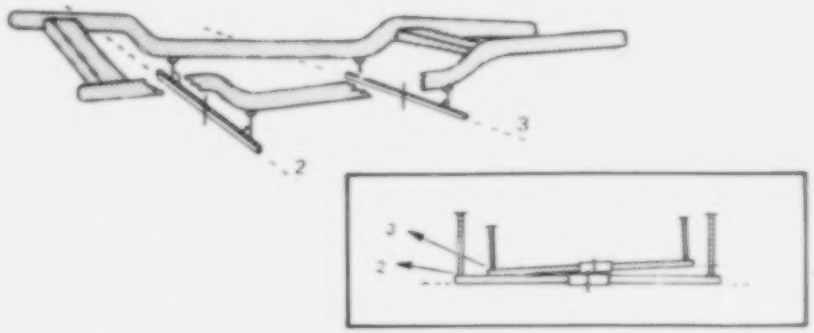
B. Prepare vehicle for gauging and analysis

JOB SHEET #5

C. Check alignment of centering gauge crossbars at front and rear of center section (Figure 66)

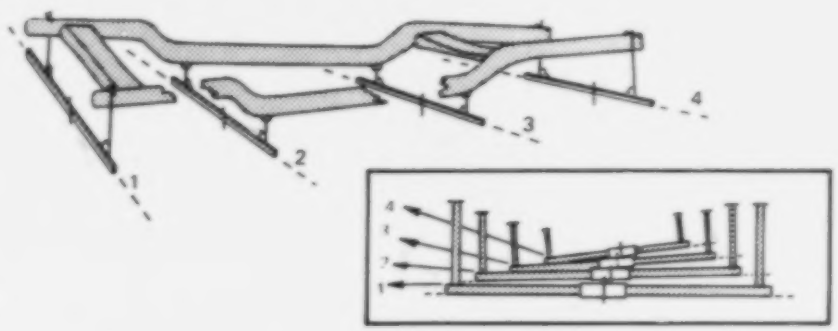
(NOTE: Begin the inspection by using the center-section gauges. Generally, twist will exist along the entire frame. However, it may be covered up by other damage in the front and rear sections. Some technicians prefer to hang only the center section gauges when checking twist.)

FIGURE 63



D. If no frame damage is apparent in the front and rear sections, confirm twist by checking alignment of other centering gauges (Figure 67)

FIGURE 67



E. Correct twist damage before gauging other types of damage

(NOTE: Repair procedures are covered in Unit II.)

F. Clean work area and return equipment and materials to proper storage

GAUGE AND ANALYZE FRAME DAMAGE
UNIT I

JOB SHEET #6 — GAUGE AND ANALYZE SIDESWAY

I. Equipment and materials

A. Centering gauges

B. Tram gauges

C. Steel tape

D. Vehicle with sidesway or simulator

E. Specification guide for vehicle

F. Supports required for vehicle

II. Procedure

A. Visually inspect vehicle for signs of sidesway

EXAMPLES:
1. Horizontal bending of frame at point of impact
2. Bending or buckling of frame at control points
3. Wheels, particularly on one side, out of line with each other but sitting in correct vertical position

B. Prepare vehicle for gauging and analysis

(NOTE: Be sure to hang gauges in damaged area.)

C. Correct any diamond or twist conditions prior to gauging sidesway

D. Check alignment of centering gauges

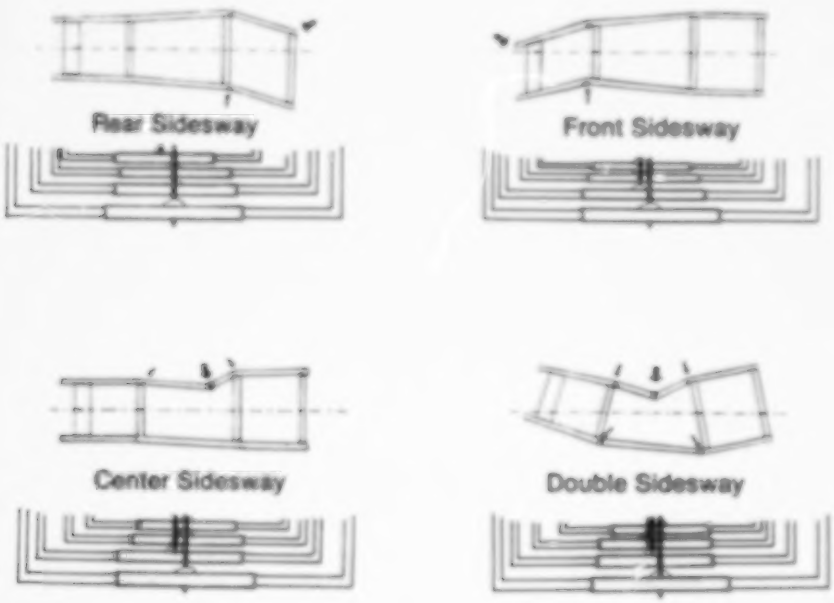
1. Check to see that crossbars are level and correctly aligned

JOB SHEET #6

2. Check alignment of sighting pins to determine sidesway (Figure 68)

(NOTE: Remember that in true sidesway, damage is relative to the centerline only, indicated by the sighting pins being out of alignment. If the crossbars are not level or the centering pins not vertical, some condition other than sidesway exists.)

FIGURE 68



F. Clean work area and return equipment and materials to proper storage

GAUGE AND ANALYZE FRAME DAMAGE
UNIT I

JOB SHEET #7 — GAUGE AND ANALYZE SAG

I. Equipment and materials

A. Centering gauges

B. Tram gauges

C. Steel tape

D. Vehicle with sag or simulator

E. Specification guide for vehicle

F. Supports required for vehicle

II. Procedure

A. Visually inspect vehicle for signs of sag

EXAMPLES:
1. Vertical bending of one or both siderails
2. Misalignment of doors
3. Front and rear ends higher than normal
4. Buckles in roof

B. Prepare vehicle for gauging and analysis

1. Hang gauges in sag damage area

2. Hang front and rear gauges in front of or behind any mash damage

C. Correct any diamond or twist damage prior to gauging sag

D. Check alignment of centering gauges

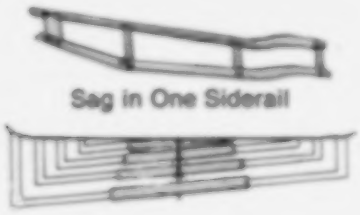
1. Check to see that sighting pins are correctly aligned

JOB SHEET #7

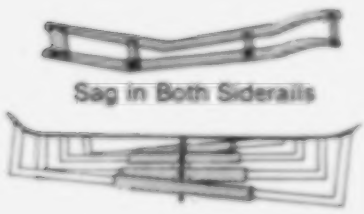
2. Check alignment of crossbars to determine sag (Figure 69)

(NOTE: Remember that in true sag only the datum alignment of the siderail or siderails is affected, indicated by the crossbars not being aligned or not being aligned proportionally. The sighting pins should be aligned, although with sag in one siderail some sighting pins may not be vertical.)

FIGURE 69



Sag in One Siderail



Sag in Both Siderails

F. Clean work area and return equipment and materials to proper storage

GAUGE AND ANALYZE FRAME DAMAGE
UNIT I

JOB SHEET #8 — GAUGE AND ANALYZE MASH

I. Equipment and materials

A. Centering gauges

B. Tram gauges

C. Steel tape

D. Vehicle with mash or simulator

E. Specification guide for vehicle

F. Supports required for vehicle

II. Procedure

A. Visually inspect vehicle for signs of mash (kick-up)

EXAMPLES:
1. Bending or buckling of frame in front or rear section
2. Buckles in hood or trunk lid
3. Misalignment of hood or trunk lid
4. Buckles in side panels
5. Gaps between body panels at center section and front or rear section
6. Misalignment of suspension or other mechanical components

B. Prepare vehicle for gauging and analysis

(NOTE: Be sure to hang gauges in damaged areas.)

C. Correct any diamond or twist damage before gauging mash

D. Check alignment of centering gauges

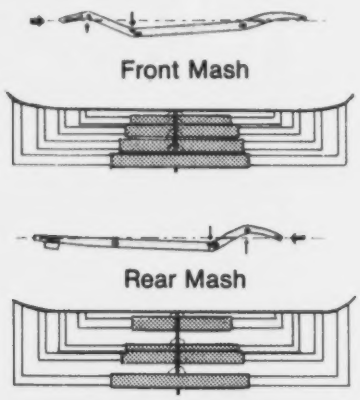
1. Check to see that sighting pins are correctly aligned

JOB SHEET #8

2. Check for crossbars above or below the datum line in the front or rear section (Figure 70)

   (NOTE: Remember that mash is damage in the front or rear section with respect to the datum line, as indicated by the alignment of the crossbars. The sighting pins should be aligned, although some sighting pins may not be vertical if mash is greater on one side than the other.)

   FIGURE 70



F. Clean work area and return equipment and materials to proper storage

GAUGE AND ANALYZE FRAME DAMAGE
UNIT I

JOB SHEET #9 — MEASURE FRAME MEMBER DISTORTION

I. Equipment and materials

A. Centering gauges

B. Tram gauges

C. Steel tape

D. Damaged vehicle

E. Specification guide for vehicle

F. Supports required for vehicle

II. Procedure

(NOTE: Measurements are taken to gauge the extent of damage and to check repairs as they are made. This job sheet will give you practice in using measuring tools to determine the extent of damage. In this procedure, you will be asked to measure certain dimensions on a vehicle and to compare them with design specifications. When gauging and analyzing damage, the measurements taken will depend on the type of damage and the method of repair.)

A. Visually inspect vehicle to determine possible types of damage

B. Prepare vehicle for gauging and analysis

C. Perform gauging and analysis to determine types of damage involved

(NOTE: For this exercise, do not repair twist or diamond damage before gauging other types of damage. Continue with procedure, using other indications to analyze types of damage involved.)

D. Indicate the types of damage you think are present on the assigned vehicle

_____1. Diamond
_____2. Twist
_____3. Sidesway
_____4. Double sidesway
_____5. Sag in one siderail
_____6. Sag in both siderails
_____7. Front mash
_____8. Rear mash

JOB SHEET #9

E. Take measurements relative to centerline and compare them to specifications guide

(NOTE: Give your answers in the same unit of measure [inches or millimeters] as that used in the guide. If the dimension asked for below is not shown in the guide, use the given dimension that is closest to that asked for.)

		Actual	Guide
1.	Front outside-to-outside of frame	_____	_____
2.	Rear outside-to-outside of frame	_____	_____
3.	Width of frame at cowl area	_____	_____
4.	Width of frame at rear door area	_____	_____
5.	Diagonal width from left cowl to right rear door	_____	_____
6.	Diagonal width from right cowl to left rear door	_____	_____
7.	Width of frame at front spring pod	_____	_____
8.	Distance from cowl to front spring pod on right side	_____	_____
9.	Width of frame at rear wheels	_____	_____
10.	Strut tower to cowl	_____	_____
11.	Strut tower to strut tower	_____	_____
12.	Lower ball joint to reference point	_____	_____

F. Circle those dimensions in step E that are out of tolerance

G. Discuss your results with your instructor

H. Clean work area and return equipment and materials to proper storage

GAUGE AND ANALYZE FRAME DAMAGE
UNIT I

TEST

NAME _____ SCORE _____

1. Match to their correct definitions terms associated with gauging and analyzing. Write the number of the correct term in the space beside each definition.

_____a. To use precision measuring tools to determine vehicle dimensions and alignments

_____b. Position of a part of a vehicle in relation to its designed position or to other parts

_____c. To determine the nature and extent of vehicle damage by studying the damage and by comparing the results of gauging the vehicle to its designed dimensions and alignments

_____d. Assembly of metal structural parts that supports the vehicle body and drive train and is in turn supported by the wheels

_____e. Vehicle design in which structural support comes from the design and construction of the body instead of a separate frame

_____f. Assembly of metal structural parts that supports part of the vehicle body and is attached to another stub frame or to a unitized body

_____g. Point on a vehicle used as a basis for gauging, analyzing, and repairing damage

_____h. Process of returning a damaged vehicle frame to its original shape and alignment

_____i. Method of attaching frame straightening equipment to pull or anchor a vehicle

_____j. Method of holding vehicle in place during straightening procedure

_____k. Application of a specific amount of force in a particular direction to correct frame damage

_____l. To check or correct the setting of a measuring device or test instrument

1. Control point
2. Frame
3. Unitized body
4. Torque box
5. Calibrate
6. Gauge
7. Stub frame
8. Alignment
9. Graduation
10. Anchor
11. Hook up
12. Analyze
13. Pull
14. Frame straightening

TEST

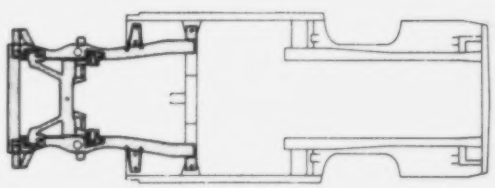
_____m. Mark on a measuring device showing the unit of measurement or fractions of the unit of measurement

_____n. Section of frame in some frame designs that twists and turns slightly to absorb shock from vehicle movement or collision

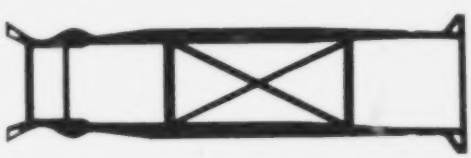
2. Identify types of frames. Study the types of frames in the list below and write the correct name in the space provided with each illustration.

Ladder-type
X-type
Perimeter
Unitized body
Combination

a. _____

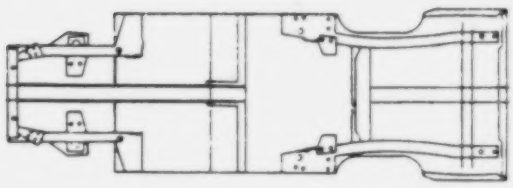


b. _____



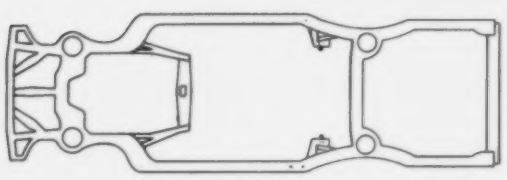
TEST

c. _____



d. _____

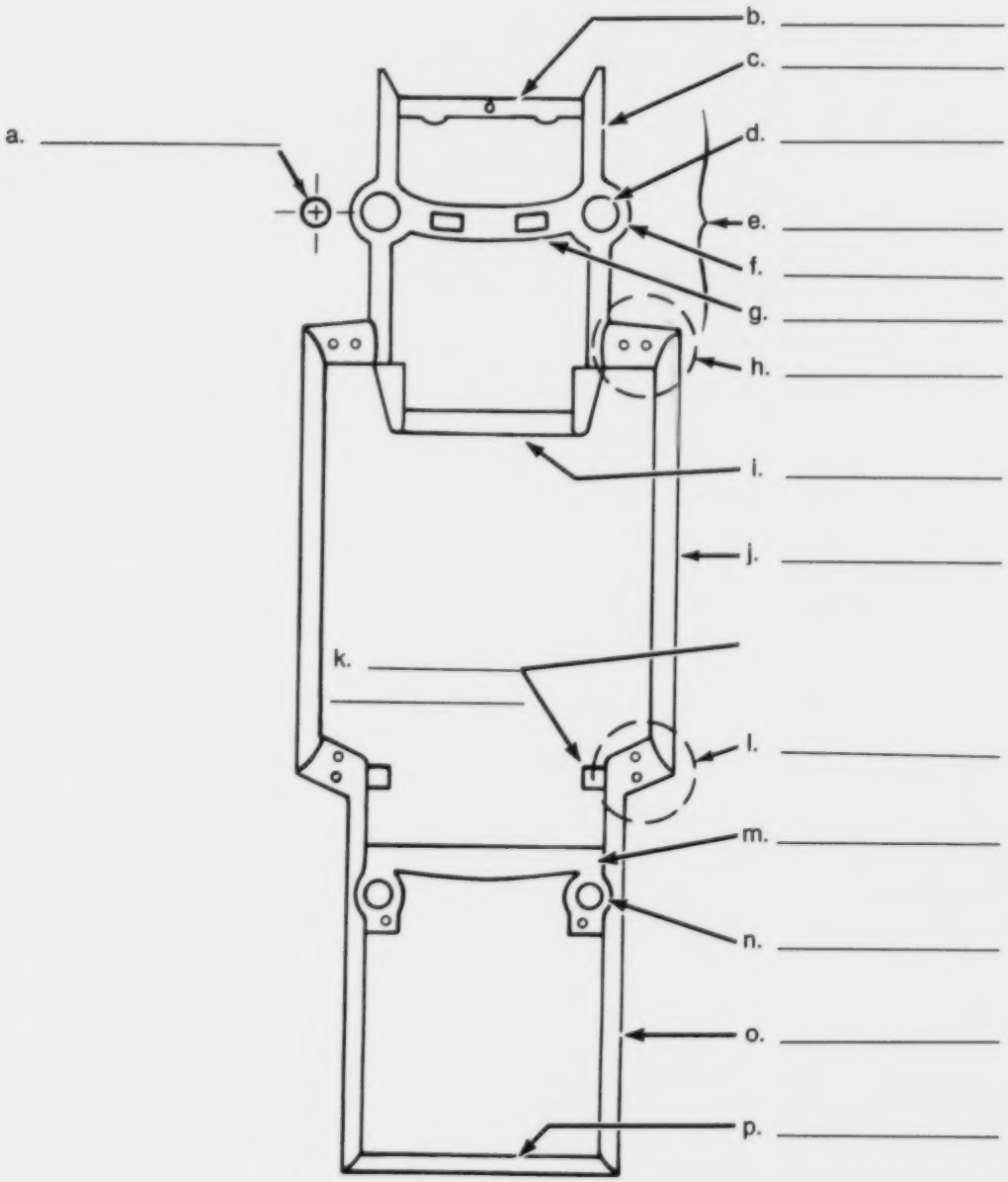
e. _____



TEST

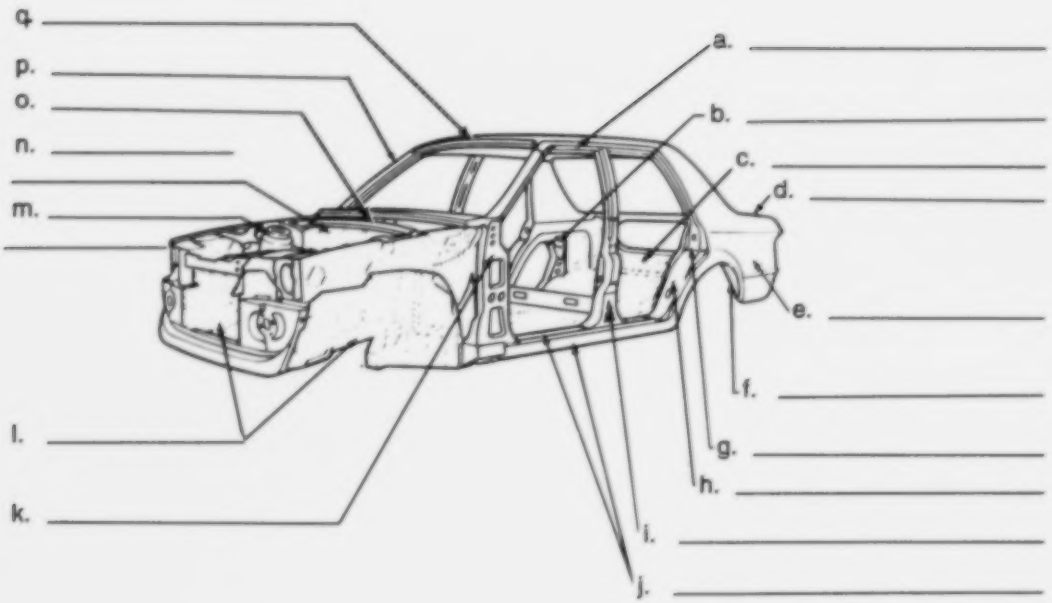
3. Label parts of common types of frames. Write the names in the spaces provided with the following illustrations.

Perimeter



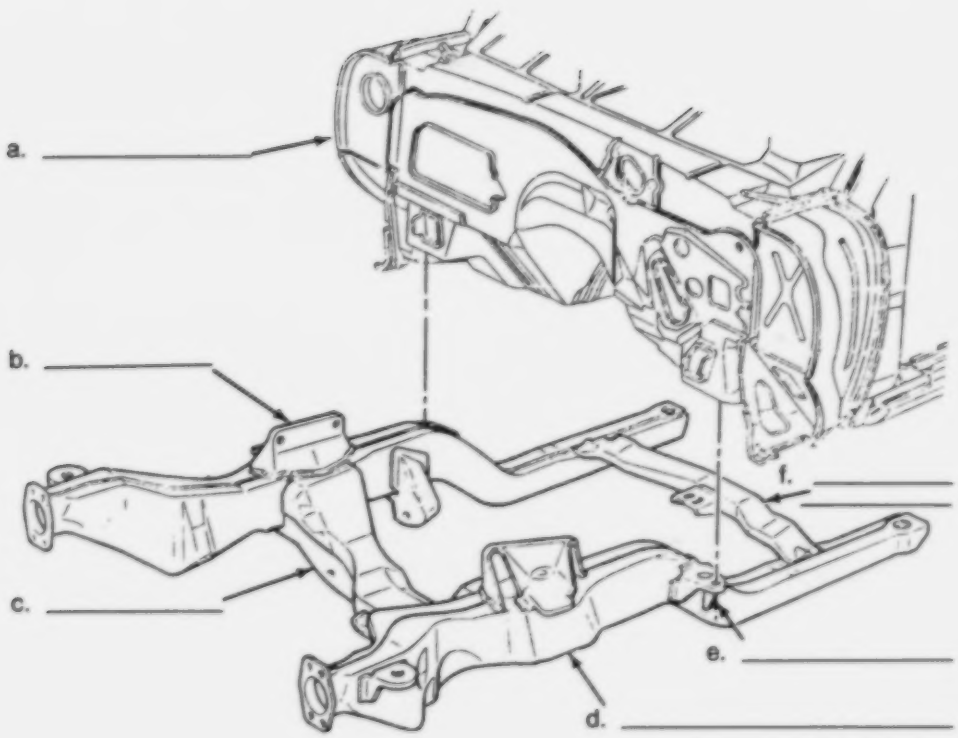
TEST

Unitized body



TEST

Combination



TEST

4. Match reference elements of damage analysis to their correct descriptions. Write the number of the correct element in the space provided beside each description.

_____a. An imaginary line running the length of the vehicle at an equal distance from each side of the frame

_____b. Condition of corresponding vehicle parts being parallel to each other

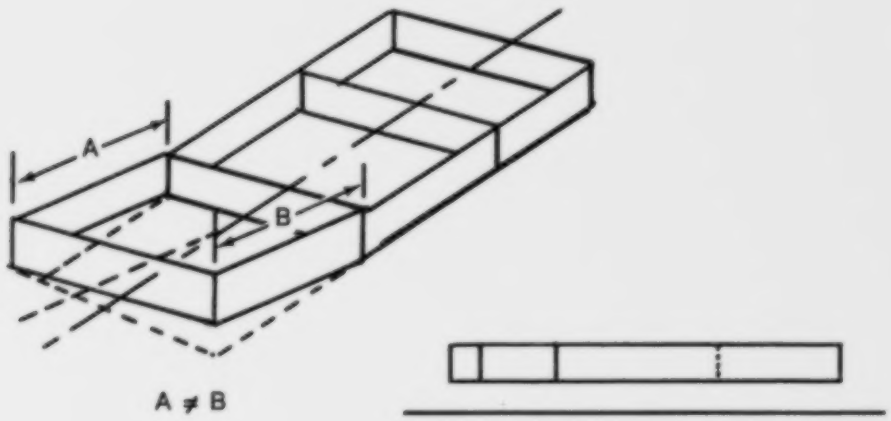
_____c. An imaginary line that serves as a base for making measurements at various points on the frame

_____d. A comparison of the actual distance between two points on the vehicle and the designed dimensions

1. Datum
2. Centerline
3. Level
4. Measurement

5. List the elements of damage analysis shown in the following representations of structural damage. Write an "X" beside each element of damage shown for each representation.

a.



_____ Centerline

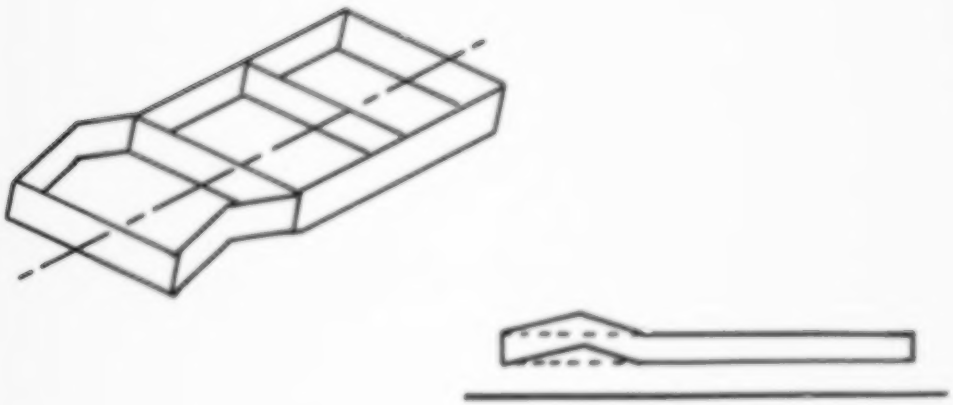
_____ Datum

_____ Level

_____ Measurement

TEST

b.



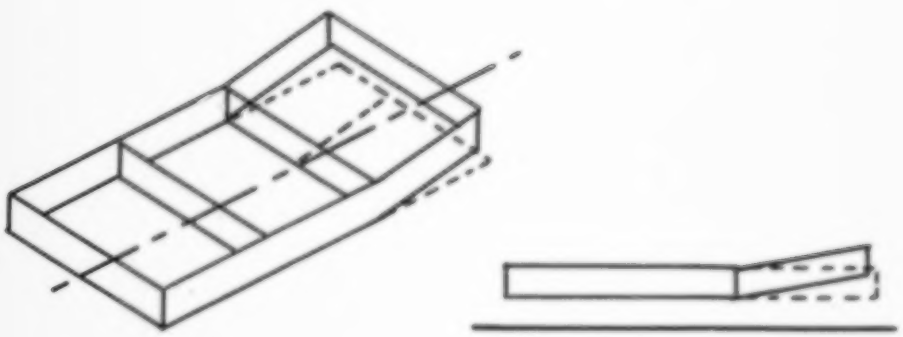
_____ Centerline

_____ Datum

_____ Level

_____ Measurement

c.



_____ Centerline

_____ Datum

_____ Level

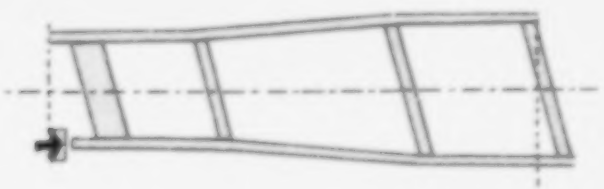
_____ Measurement

TEST

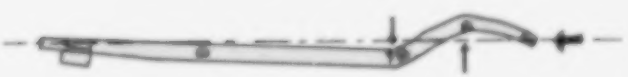
6. Identify types of frame and unitized body damage. Study the list below and write the correct name of the damage shown in the illustrations.

Sidesway from front-end impact
Sidesway from impact at rear
Sidesway from impact at center
Double sidesway from impact at center
Diamond
Sag from front impact
Sag from rear impact
Mash from front impact
Mash from rear impact
Twist

a. _____



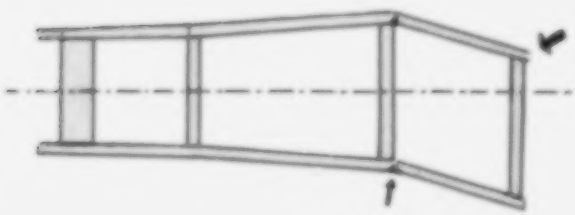
b. _____



TEST

c. _____

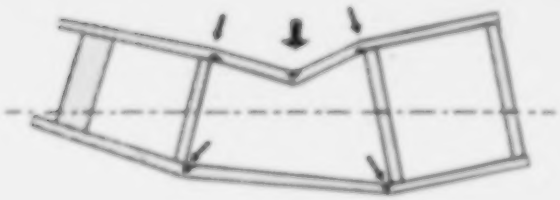
d. _____



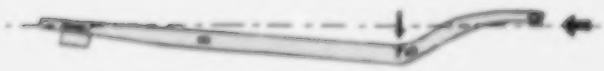
e. _____

TEST

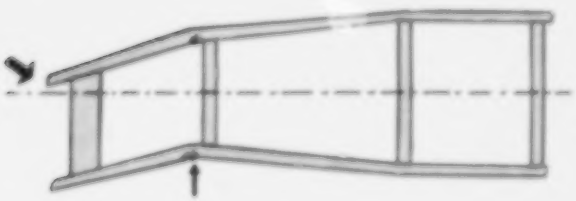
f. _____



g. _____

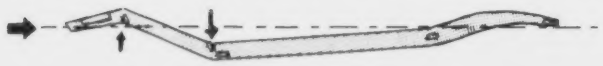


h. _____

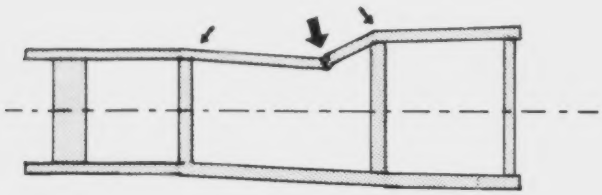


TEST

i. _____

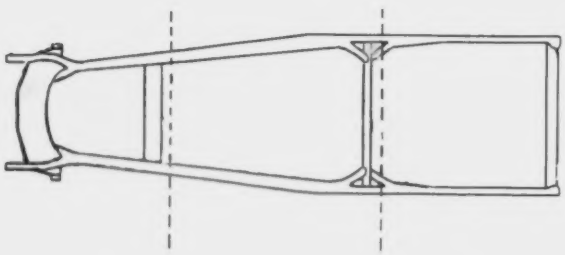


j. _____



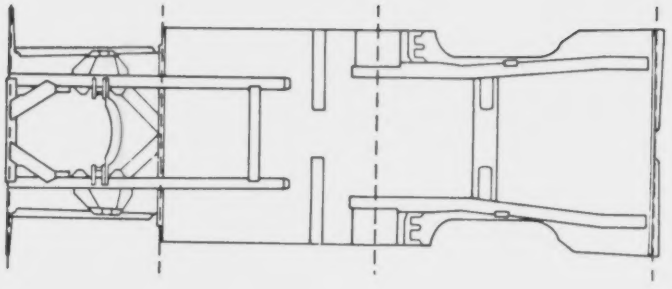
7. Label frame repair control points. Draw lines to the control points in the drawings below and label the lines with the name of the control points.

   a. Conventional frame



TEST

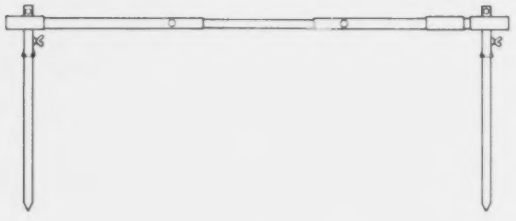
b. Unitized body



8. Identify equipment used in gauging damage. Study the list below and write the correct names in the space provided with the illustrations that follow.

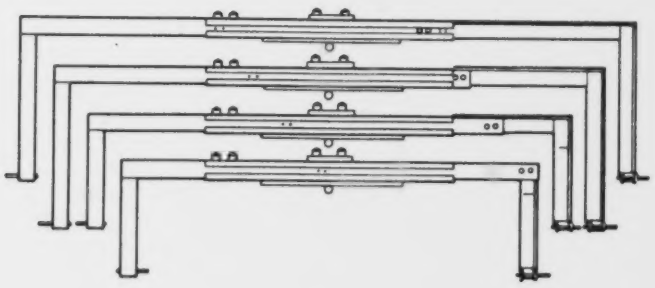
Centering gauge
Combination centering gauge and datum-line gauge
Tram gauge
Tape measure
Tracking gauge
Laser-beam gauging system
Bench

a. _____

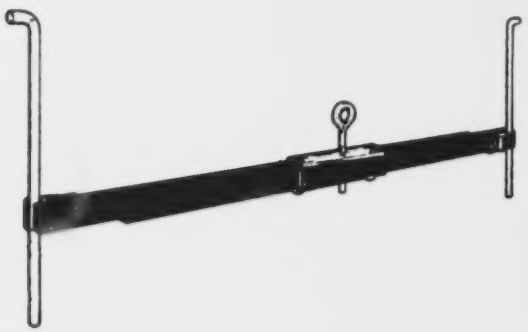


TEST

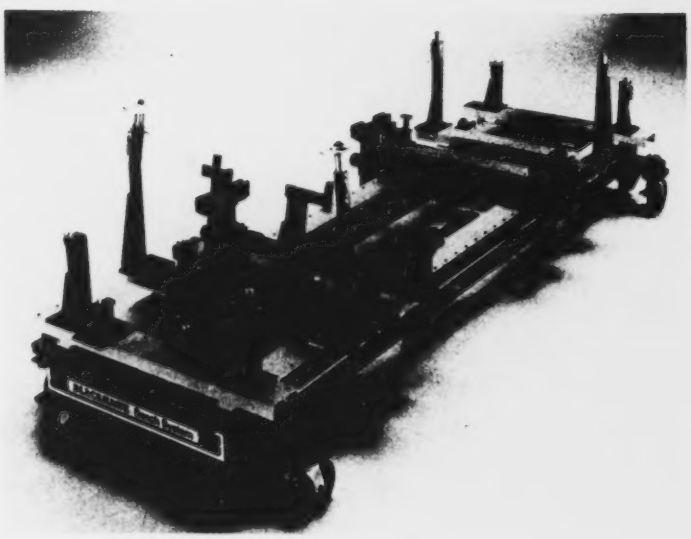
b. _____



c. _____

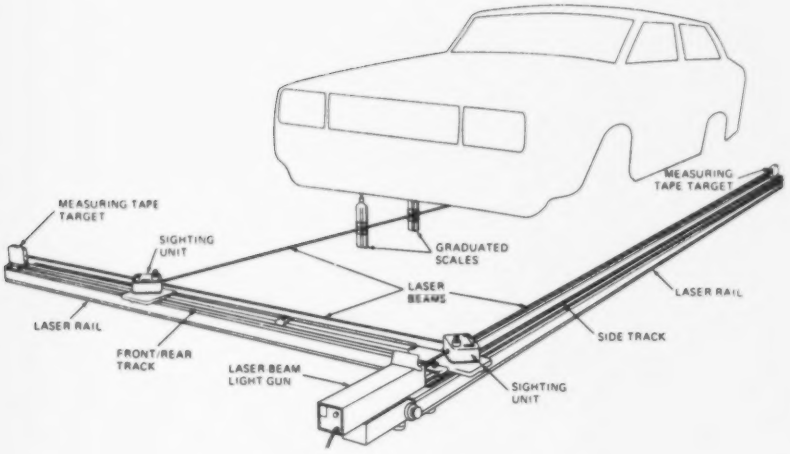


d. _____

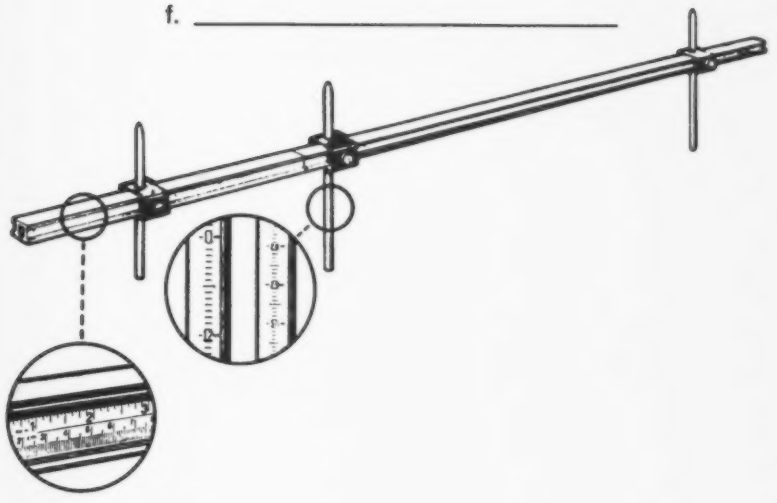


TEST

e. _____

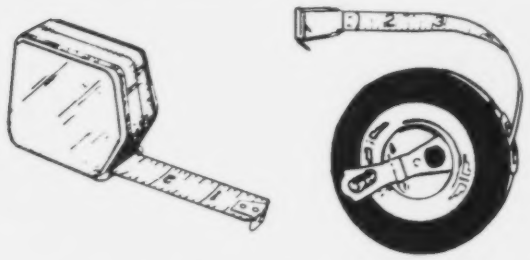

MEASURING TAPE TARGET
SIGHTING UNIT
GRADUATED SCALES
LASER BEAMS
LASER RAIL
SIDE TRACK
SIGHTING UNIT
LASER BEAM LIGHT GUN
FRONT/REAR TRACK
LASER RAIL
MEASURING TAPE TARGET

f. _____

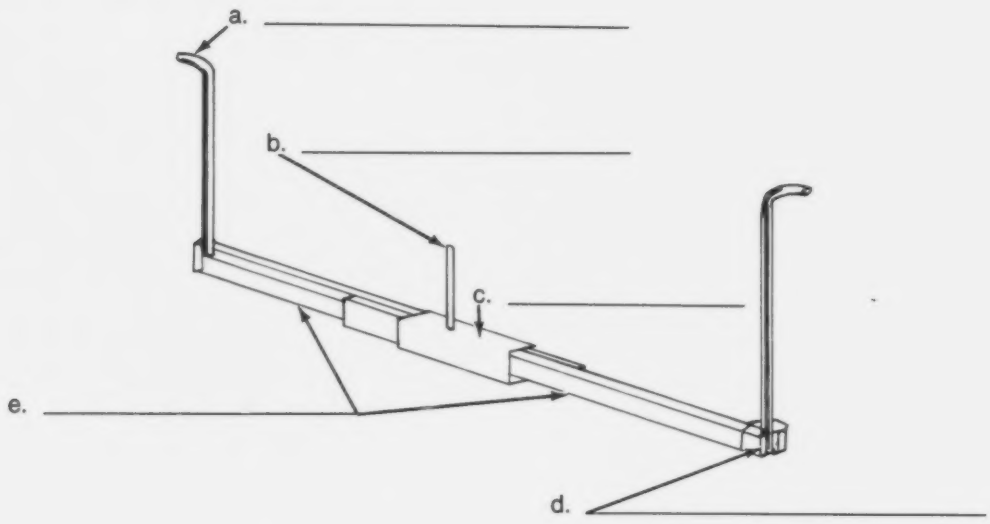


TEST

g. _____



9. Label the parts of a centering gauge. Write the correct names in the spaces provided.



10. List methods of installing centering gauges. Write four methods in the space provided.

a. _____

b. _____

c. _____

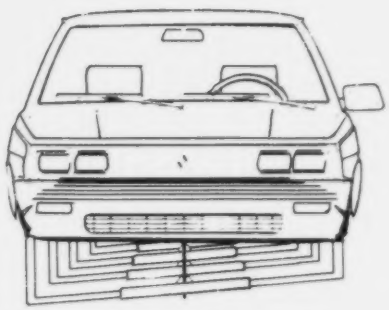
d. _____

TEST

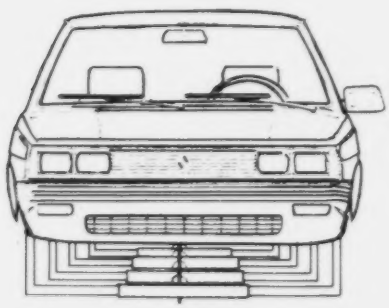
11. Use centering gauge alignments to identify types of damage. Write the correct name of the damage indicated by the centering gauges in the following drawings.

Sidesway **Mash**
Diamond **Twist**
Sag

a. _____

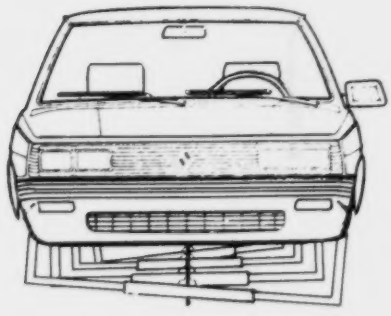


b. _____

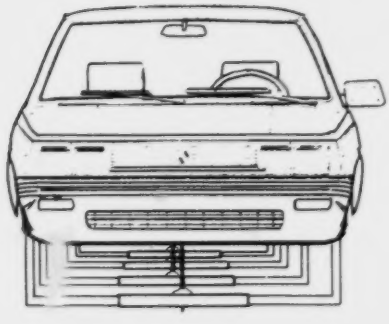


TEST

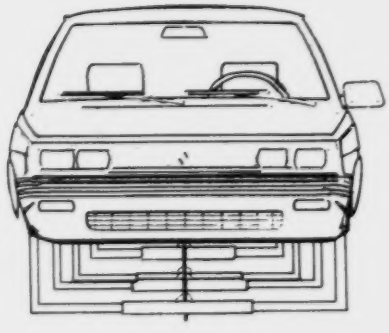
c. _____



d. _____



e. _____



TEST

12. Select from a list guidelines for installing centering gauges. Write an "X" in the space beside each correct guideline below.

_____a. Elevate vehicle and rest on level surface with supports adjusted to provide correct datum line

_____b. Install two gauges as far apart from each other as possible

_____c. Avoid installing gauges in damaged area as this will distort readings

_____d. Install ends of gauges at corresponding locations on each side of frame

_____e. Remove gauges before making repairs

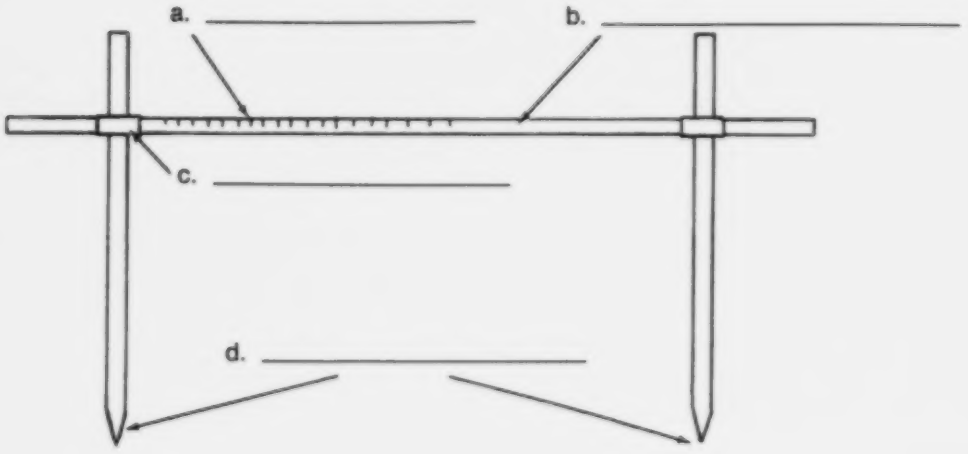
_____f. Keep gauges clean and calibrated

_____g. Sight 6 to 8 feet from vehicle, while standing on vehicle centerline

_____h. Scan ends of crossbars with both eyes open to check for parallel alignment

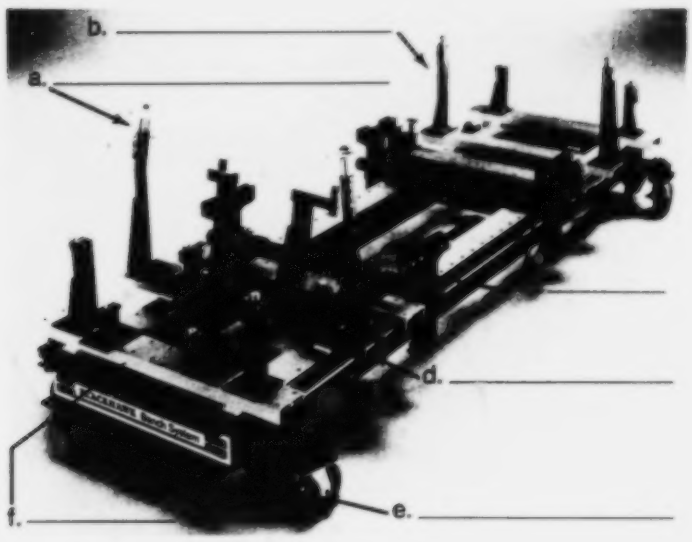
_____i. Check sighting pins for alignment by looking down row of pins with one eye closed

13. Label the parts of a tram gauge. Write the names of the parts in the figure below.



TEST

14. Label the parts of a universal bench. Write the names of the parts in the figure below.



15. Arrange in order the sequence for analyzing damage. Write a "1" by the first step, a "2" by the second step, and so on.

_____a. Remove any parts that will prevent accurate gauging

_____b. Gauge and correct diamond or twist

_____c. Locate control points

_____d. Determine vehicle's three sections

_____e. Establish a base by hanging four centering gauges

_____f. Gauge and correct datum misalignment in center section

_____g. Gauge and correct datum misalignment in end sections

_____h. Gauge and correct centerline misalignment

_____i. Gauge and correct level misalignment in end sections

_____j. Gauge and correct level misalignment in center section

TEST

(NOTE: Test items 16 and 17 list the assignment sheet and the job sheet. They are an important part of this test. If they have not been completed, check with your instructor.)

16. Use specification guides to determine gauging dimensions.

17. Demonstrate the ability to

    a. Clean and calibrate a centering gauge.

    b. Prepare vehicle for gauging and analysis.

    c. Position vehicle on bench.

    d. Gauge and analyze diamond.

    e. Gauge and analyze twist.

    f. Gauge and analyze sidesway.

    g. Gauge and analyze sag.

    d. Gauge and analyze mash.

    i. Measure frame member distortion.

GAUGE AND ANALYZE FRAME DAMAGE
UNIT I

ANSWERS TO TEST

1.

a.	6	f. 7	k. 13
b.	8	g. 1	l. 5
c.	12	h. 14	m. 9
d.	2	i. 11	n. 4
e.	3	j. 10	

2.
a. Combination
b. X-type
c. Unitized body
d. Ladder-type
e. Perimeter

3. **Perimeter**

a. Lower ball joint
b. Front cross member
c. Frame horn
d. Upper control arm shim contact point
e. Front frame rail
f. Spring pod
g. Main cross member
h. Torque box
i. Transmission support member
j. Frame side rail
k. Stabilizer mount
l. Torque box
m. Rear suspension cross member
n. Rear spring pod
o. Rear frame stub
p. Rear cross member

Unitized body

a. Roof side rail
b. Rear shock tower
c. Rear cross member
d. Deck lid
e. Rear rail
f. Rear quarter panel
g. Wheel house
h. Dog leg
i. Rear lock pillar
j. Inner and outer rocker panels
k. Front body hinge pillar
l. Inner and outer front rails
m. Strut tower
n. Firewall
o. Cowl top panel
p. Windshield pillar
q. Header bar

Combination

a. Unitized body section
b. Stub frame section
c. Front main crossmember
d. Side rail
e. Mounting bracket
f. Rear crossmember

4.

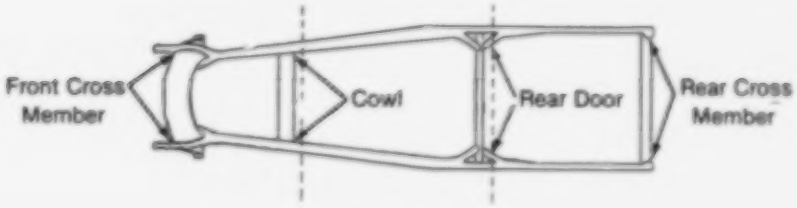
a.	2	c.	1
b.	3	d.	4

ANSWERS TO TEST

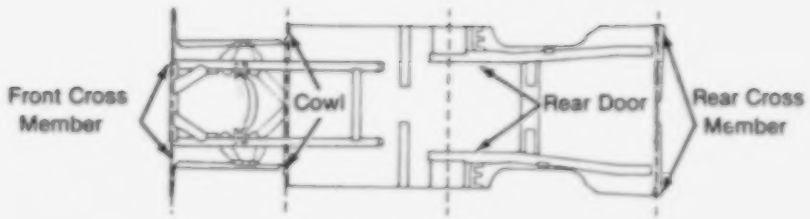
5. a. Centerline, level, measurement
   b. Datum
   c. Centerline, datum

6. a. Diamond
   b. Mash from rear impact
   c. Sag from front impact
   d. Sidesway from impact at rear
   e. Twist
   f. Double sidesway from impact at center
   g. Sag from rear impact
   h. Sidesway from front-end impact
   i. Mash from front impact
   j. Sidesway from impact at center

7. a. Conventional frame



   b. Unitized body



ANSWERS TO TEST

8. a. Tram gauge
   b. Centering gauge
   c. Combination centering gauge and datum line gauge
   d. Bench
   e. Laser-beam gauging system
   f. Tracking gauge
   g. Tape measure

9. a. Adjustable hanger
   b. Sighting pin
   c. Arm clamp
   d. Hanger clamp
   e. Arms

10. (Answer should include four of the following)

    a. Mounted in hole
    b. Resting on top of frame
    c. Resting on top of channel
    d. Hung with extension
    e. Hung with offset adaptor
    f. Hung with magnetic attachment

11. a. Diamond
    b. Mash
    c. Twist
    d. Sidesway
    e. Sag

12. a, d, f, g, h, i

13. a. Graduations
    b. Crossbar
    c. Adjustable clamp
    d. Pointers

14. a. Strut tower fixture
    b. Fixture
    c. Anchor rails
    d. Longitudinal rail
    e. Caster
    f. Fixture rail

15. a. 3
    b. 5
    c. 2
    d. 1
    e. 4
    f. 8
    g. 10
    h. 6
    i. 9
    j. 7

16. Evaluated to the satisfaction of the instructor.

17. Performance skills evaluated to the satisfaction of the instructor.

ALIGN FRAME
UNIT II

UNIT OBJECTIVE

After completing this unit, the student should be able to repair various types of damage occurring in a variety of frame and unitized body designs. The student will show this ability by completing assignment sheets, job sheets, and unit test with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match to their correct definitions terms associated with frame alignment.
2. List the major actions performed during frame alignment.
3. Identify types of frame straighteners.
4. Match types of frame straighteners to their correct uses.
5. Label the major parts of a bench used in combination with a rail frame straightener.
6. Identify types of clamps and hooks used in frame alignment.
7. State safety rules to observe when using frame alignment equipment.
8. Select from a list guidelines for the operation of frame alignment equipment.
9. Identify types of pulls used in frame alignment.
10. Plan repair sequence.
11. Use specification guide to determine proper hook-up points.
12. Demonstrate the ability to
    a. Inspect and perform routine maintenance on hydraulic equipment.
    b. Prepare vehicle for frame alignment.
    c. Align diamond damage.
    d. Align twist damage.
    e. Align sidesway damage.
    f. Align sag damage.
    g. Align mash damage.

ALIGN FRAME
UNIT II

SUGGESTED ACTIVITIES

I. Unit contents

A. Objective sheet

B. Suggested activities

C. Supplement #1 — Specification Guides for Vehicles Used in Assignment Sheets

D. Information sheet

E. Assignment sheets

1. Assignment Sheet #1 — Plan Repair Sequence

2. Assignment Sheet #2 — Use Specification Guide to Determine Hook-Up Points

F. Answers to assignment sheets

G. Job sheets

1. Job Sheet #1 — Inspect and Perform Routine Maintenance on Hydraulic Equipment

2. Job Sheet #2 — Prepare Vehicle for Frame Alignment

3. Job Sheet #3 — Align Diamond Damage

4. Job Sheet #4 — Align Twist Damage

5. Job Sheet #5 — Align Sidesway Damage

6. Job Sheet #6 — Align Sag Damage

7. Job Sheet #7 — Align Mash Damage

H. Unit test

I. Answers to test

II. Instructor's guide

A. Review unit and plan presentation.

SUGGESTED ACTIVITIES

B. Obtain materials needed to supplement unit.

1. Media — *Frame Damage Analysis and Correction*. Available from Teaching Aids Incorporated, Post Office Box 1798, Costa Mesa, California 92628-0798.

2. Pamphlets, slides , transparencies, and other materials from the manufacture of your frame straightening equipment.

   (NOTE: Many manufacturers of frame straightening equipment produce training aids for use with their equipment. Contact the manufacturer for such materials.)

3. Frame damage simulator

4. Transparencies and competency profiles

   (NOTE: Transparencies and competency profiles for this manual are available from the State Department of Vocational and Technical Education, Curriculum and Instruction Materials Center, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074)

C. Provide students with unit.

D. Introduce unit.

SUGGESTIONS:

- Review unit and specific objectives, relating them to each other and to previous units.
- Briefly point out equipment in your shop that is used in frame straightening.
- Show before and after pictures of repairs involving frame damage.

E. Discuss information sheet.

1. Use Information Sheet, Section I to discuss terms associated with frame alignment.

   SUGGESTIONS:

   - Review frame design and construction using transparencies from previous unit.
   - Use actual tools and equipment to illustrate other terms.

2. Use Information Sheet, Section II to discuss the major actions performed during frame alignment.

SUGGESTED ACTIVITIES

SUGGESTIONS:

- Show and demonstrate the equipment involved.
- Show illustrations or photographs of various set-ups to align frames.
- Use block and tackle or a fulcrum and lever to discuss the mechanics involved in frame straightening.
- Demonstrate what happens when excessive force is used; relate force to the metal, damage, design, and straightening process.

3. Use Information Sheet, Sections III and IV to discuss types of frame straighteners and their functions.

SUGGESTIONS:

- Point out the major parts and functions of the frame straighteners in your shop, relating them to the types discussed.
- Tour other body shops to see a variety of straightening equipment.
- Demonstrate Job Sheet #1 and allow students to practice procedure.

4. Use Information Sheet, Section V to discuss major parts of a bench and straightener combination, emphasizing equipment used in your shop.

SUGGESTIONS:

- Set up various combinations of the frame straightening equipment used in your shop, relating the equipment to advantages in particular applications.
- Show *Frame Damage Analysis and Correction* or other media demonstrating the use of equipment.
- Demonstrate Job Sheet #2 and allow students to practice, using various types of damage and set-ups.

5. Use Information Sheet, Section VI to discuss types of clamps and hooks, demonstrating those available in your shop and explaining their uses.

6. Use Information Sheet, Sections VII and VIII to discuss safety rules and guidelines for use in aligning frames.

SUGGESTIONS:

- Explain the logic behind the safety rules and guidelines and point out possible consequences of violating rules and guidelines.

SUGGESTED ACTIVITIES

- Review other pertinent safety rules.
- Demonstrate those rules and guidelines that may need clarification.

7. Use Information Sheet, Section IX to discuss types of pulls used in frame alignment, relating the pulls to various types of damage.

   SUGGESTIONS:

   - Modify the pulls as required, emphasizing how they can be made with your equipment.
   - Tie the safety rules and guidelines to making the hook ups and pulls.
   - Talk the students through the analysis and correction of frame damage in a couple of different vehicles.
   - Provide students with Assignment Sheets #1 and #2.

     (NOTE: Use the specification guides available in your shop if possible. If necessary, use the specifications provided in Supplement #1.)

   - Assign damaged vehicles to various students and allow them to complete assignment sheets for those vehicles.
   - Demonstrate remaining Job Sheet procedures and allow student practice.

     (NOTE: Because it is unlikely that you will find damage as described by types, you may want to use simulators or discuss the pulls required for each type of damage. Job Sheets #3-#7 are given in the recommended order of repair. However, you may want to teach them in some other order. For example, you may want to teach the procedures using straight, uncomplicated pulls and proceed to more complex pulls.)

F. Review unit.

G. Give test.

H. Critique test and discuss in class.

I. Reteach and retest as required.

J. Complete appropriate section of competency profile.

III. Unit references

A. Coghlan, David A. *Automotive Chassis Systems: Steering, Suspension, Alignment, and Brakes*, 2nd ed. Boston: Breton Publishers, a division of Wadsworth, Inc., 1985.

SUGGESTED ACTIVITIES

B. Crouse, William H., and Donald L. Anglin. *Automotive Body Repair and Refinishing*, 2nd ed. New York: McGraw-Hill Book Company/Gregg Division, 1986.

C. *Gauging and Analyzing Collision Damage.* Grand Island, Nebraska: Chief Automotive Systems, 1978.

D. Manual, Edward F., and Wayman R. Penner. *Auto Body Repair and Repainting.* Stillwater, Oklahoma: State Department of Vocational and Technical Education/ Curriculum and Instructional Materials Center, 1974.

E. *The New Science of Unibody Repair.* Milwaukee, Wisconsin: Blackhawk Applied Power, Inc., Automotive Division, 1982.

F. Rhone, L.C., and H. David Yates. *Total Auto Body Repair.* 2nd ed. Indianapolis: Bobbs-Merrill Educational Publishing, 1983.

ALIGN FRAME
UNIT II

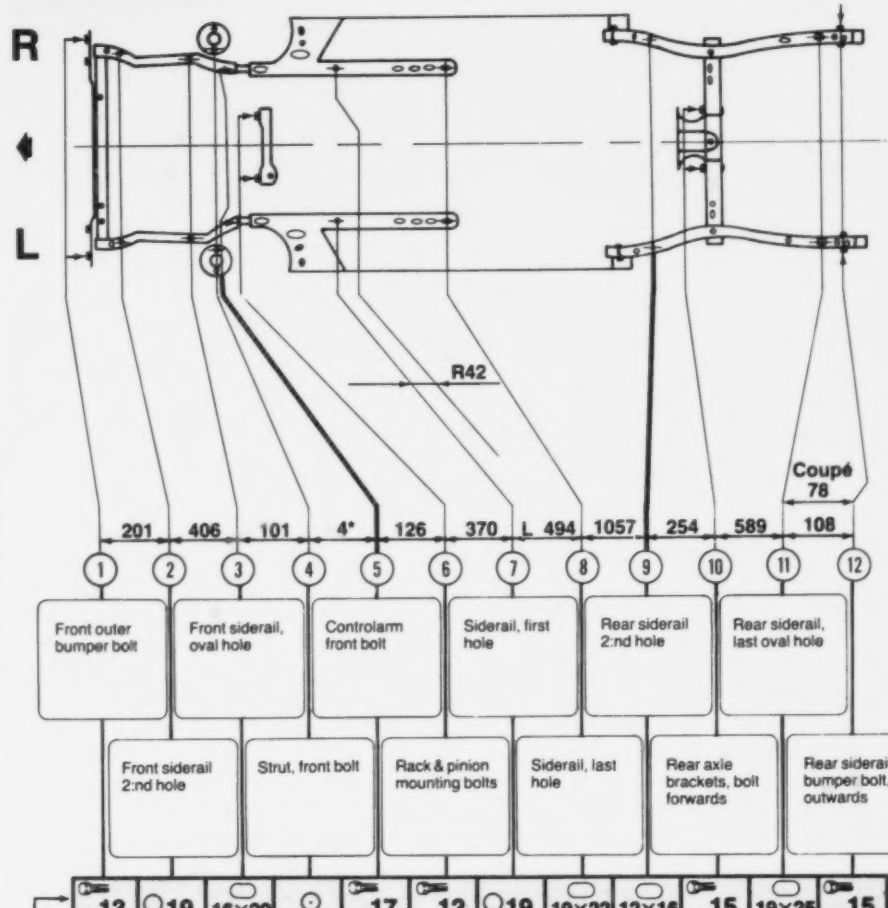
SUPPLEMENT #1 — SPECIFICATION GUIDES FOR VEHICLES
USED IN ASSIGNMENT SHEETS

(NOTE: Use these as handouts only if actual specification guides are not available. You may wish to change the vehicles on the assignment sheets to some for which you have guides.)

Dataliner

FORD Escort
MERCURY Lynx
Coupe, Wagon
1985½–

5084



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3	1	1	1	1	3K	1	1	1	2	1	1
300	100	200	600	–	100	–	–	100	100	200	200
190	197	190	236	241	226	162	167	163	171	182	219
2759	2558	2152	4*	2047	1920	1551	1057	0	254	843	951
712	511	105	4*	0	127	496	990	2047	2301	2890	2998
1103	969	918	842	727	–	711	703	1044	303	1042	1111
551	484	459	421	363	R 163 L 126	355	351	522	151	521	555

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FORD Escort
MERCURY Lynx
Coupe, Wagon **1985½–**

5084

① Pare-chocs, boulon avant extérieur
② Longeron avant, trou deuxième
③ Longeron avant, trou ovale
④ Jambe suspension, boulon avant
⑤ Bras porteur, boulon avant
⑥ Crémaillière, boulons fixation
⑦ Longeron, trou premier
⑧ Longeron, trou dernier
⑨ Longeron arrière, trou deuxième
⑩ Fixation essieu arrière, boulon, en avant
⑪ Longeron arrière, trou dernier ovale
⑫ Longeron arrière, boulon pare-chocs, extérieur

① Stossfänger, vorderer äusserer Bolzen
② Vorderer Seitenbalken, zweites Loch
③ Vorderer Seitenbalken, ovales Loch
④ Federbein, vorderer Bolzen
⑤ Tragarm, vorderer Bolzen
⑥ Zahnstange, Befestigungsbolzen
⑦ Seitenbalken, erstes Loch
⑧ Seitenbalken, letztes Loch
⑨ Hinterer Seitenbalken, zweites Loch
⑩ Hinterachsebefestigung, Bolzen vorwärts
⑪ Hinterer Seitenbalken, letztes ovales Loch
⑫ Hinterer Seitenbalken, Stossfängerbolzen, aussen

① Front outer bumper bolt
② Front siderail, second hole
③ Front siderail, oval hole
④ Strut, front bolt
⑤ Control arm, front bolt
⑥ Rack and pinion, mounting bolts
⑦ Siderail, first hole
⑧ Siderail, last hole
⑨ Rear siderail, second hole
⑩ Rear axle brackets, bolt forwards
⑪ Rear siderail, last oval hole
⑫ Rear siderail, bumper bolt, outwards

① Parachoques, perno frontal exterior
② Larguero frontal, agujero segundo
③ Larguero frontal, agujero oval
④ Pata de suspensión, perno frontal
⑤ Brazo portador, perno frontal
⑥ Cremallera, perno de montaje
⑦ Larguero, agujero, primero
⑧ Larguero, agujero ultimo
⑨ Larguero posterior, agujero segundo
⑩ Fijación eje posterior, perno adelante
⑪ Larguero posterior, agujero ultimo oval
⑫ Larguero posterior, perno parachoques, hacia afuera

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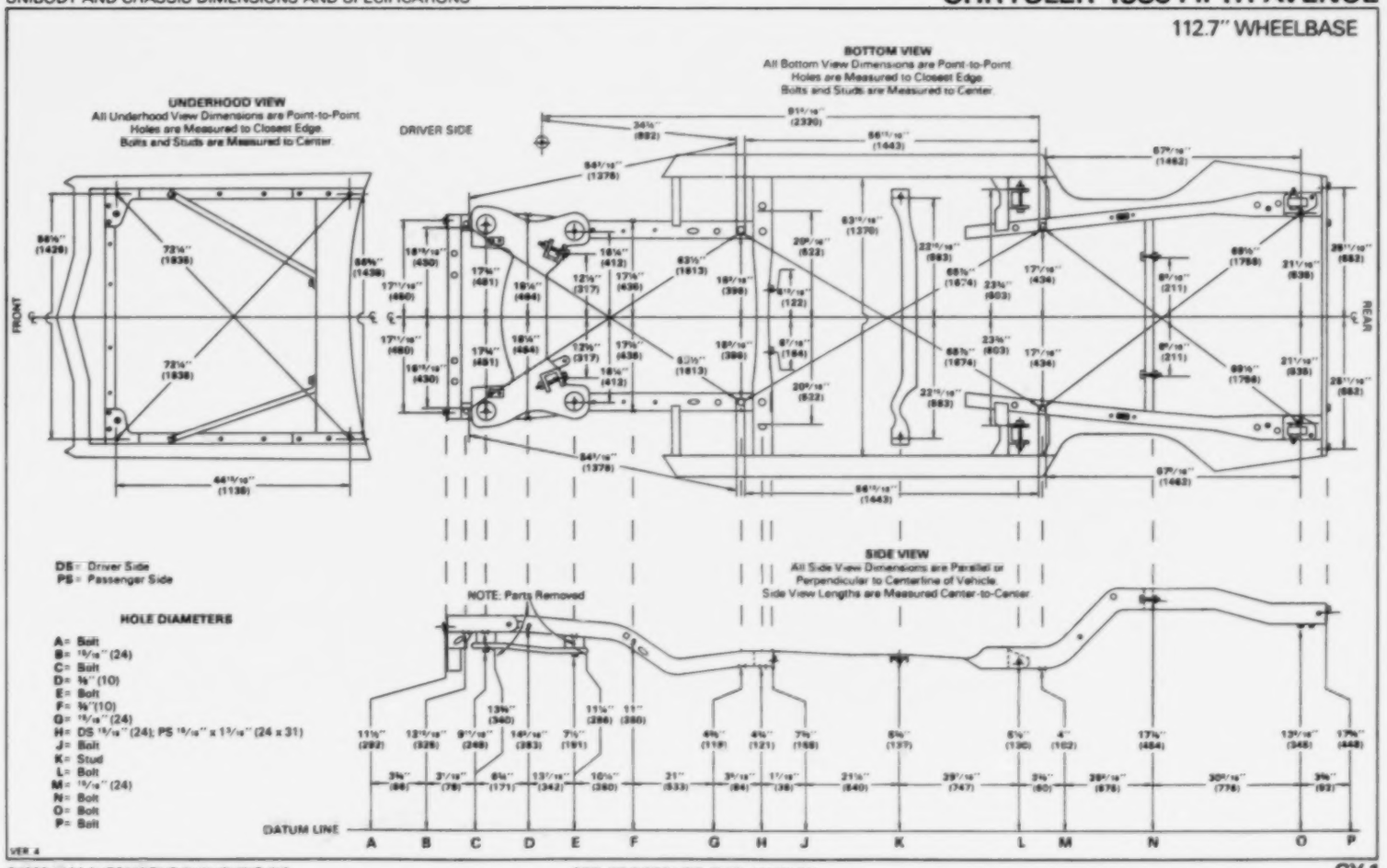
UNIBODY AND CHASSIS DIMENSIONS AND SPECIFICATIONS

CHRYSLER 1986 FIFTH AVENUE

112.7" WHEELBASE



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SEE PROCEDURE EXPLANATION

CY-1

ALIGN FRAME
UNIT II

INFORMATION SHEET

I. Terms and definitions

A. Frame rail — The side rails of the frame system which are tied together with cross members and braces to form the frame of a vehicle

B. Frame horn — That portion of the frame ahead of the front cross member where the bumper system attaches to the frame

C. Cross member — Frame sections used to tie the two frame rails together to form the frame

D. Pinch weld — Two flanges welded together along their edges; type of construction found where the rocker panel welds to the floor pan

E. Portable frame unit — Frame straightening unit that can be moved from vehicle to vehicle to straighten the frame and body

F. Stationary frame unit — Frame straightening system that is stationary and the vehicle must be placed on it for frame and body straightening purposes

G. Self-tightening clamp — Type of frame clamp where increased pressure makes the jaws of the clamp pull taut on the metal

H. Underbody clamp — Type of clamp used to anchor along pinch welds

I. Pull plate — A plate used to bolt to the frame, providing a pull location where one is not available in the frame

J. Anchor — Tie down points to hold the vehicle when using frame straightening units

K. Multiple hookup — Performing several pulls at the same time

L. Combination damage — Several types of frame damage occurring at the same time

EXAMPLES: Mash, twist, diamond, or others

M. Fishplating — Strengthening a frame by welding a plate or rail to it

II. Major actions performed during frame alignment

A. Anchoring

(NOTE: The vehicle is held in position to allow proper alignment.)

INFORMATION SHEET

B. Blocking

(NOTE: Blocks are placed at specific points along the frame to adjust alignment and to provide leverage points for pushing and pulling actions.)

C. Pulling/pushing

(NOTE: Pressure is applied to the frame or frame and body to return them to their original shapes. One of the most important things for the technician to learn is that the power of the pulling and pushing is not the key to successful frame straightening. The real secret is in proper anchoring and blocking with the pulling or pushing equipment hooked up correctly, in the proper places, and in a sufficient number of places so that the power is evenly applied over the damaged area.)

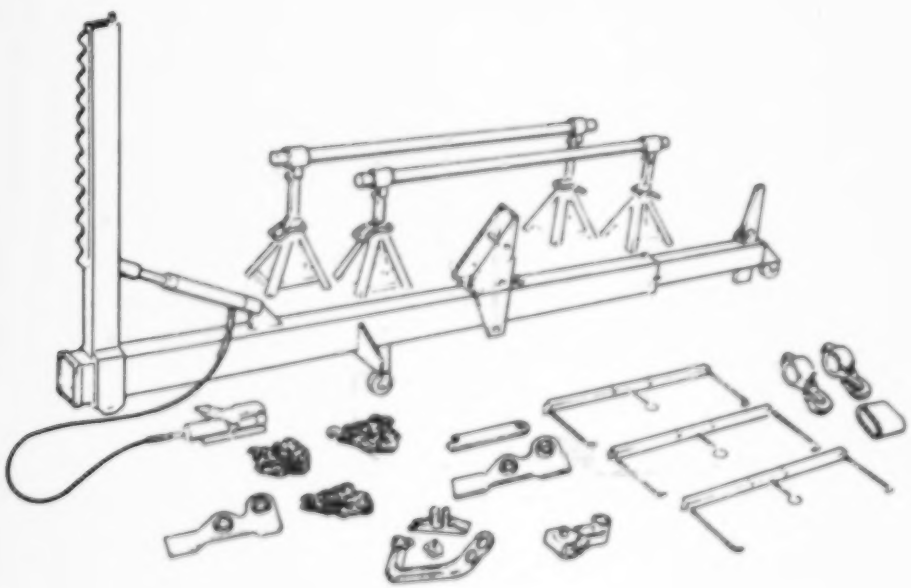
III. Types of frame straighteners (Figures 1-5)

(NOTE: The four major types of frame straighteners are often used in combination with each other.)

A. Portable

(NOTE: Portable frame straighteners are convenient and relatively inexpensive. They can be moved around the shop and easily stored out the way when not in use.)

FIGURE 1



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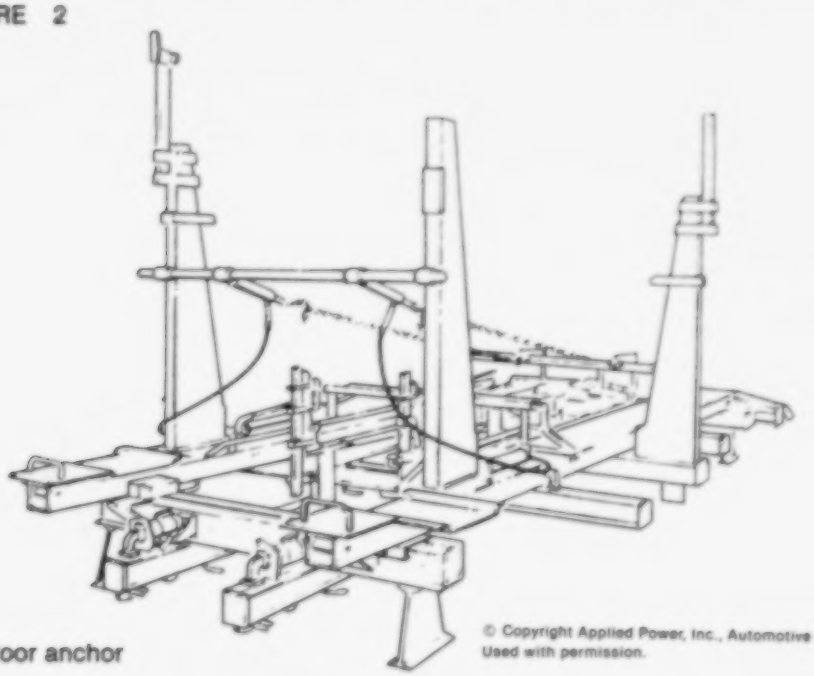
INFORMATION SHEET

B. Stationary

(NOTE: Stationary frame straighteners are bolted to the shop floor and cost much more than portable units. However, they allow multiple hook-ups to be made and, in that way, they are more efficient in correcting damage.)

FIGURE 2



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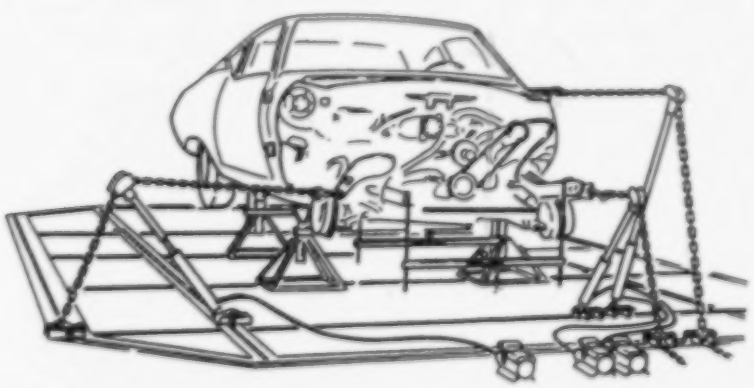
C. Floor anchor

(NOTE: Floor anchor straighteners use rails or anchor points mounted in the floor to hold equipment in place and to provide anchors for making pulls and pushes.)

FIGURE 3



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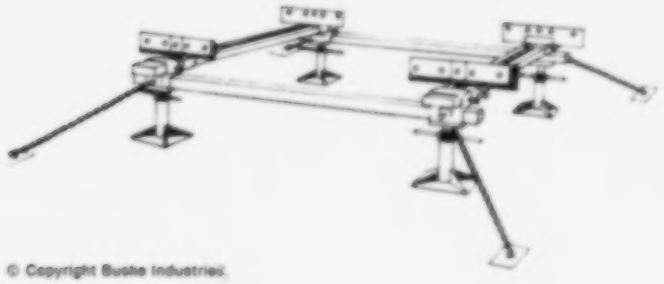
INFORMATION SHEET

D. Frame clamp

(NOTE: The frame clamp is used to clamp the pinch weld on unitized bodies. Jacks are then used to pull the underbody into position.)

FIGURE 4



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IV. Uses of frame straighteners

A. Portable — For straightening limited frame damage areas where few hook ups are required

B. Stationary — For straightening any type of frame damage on any size of conventional vehicle

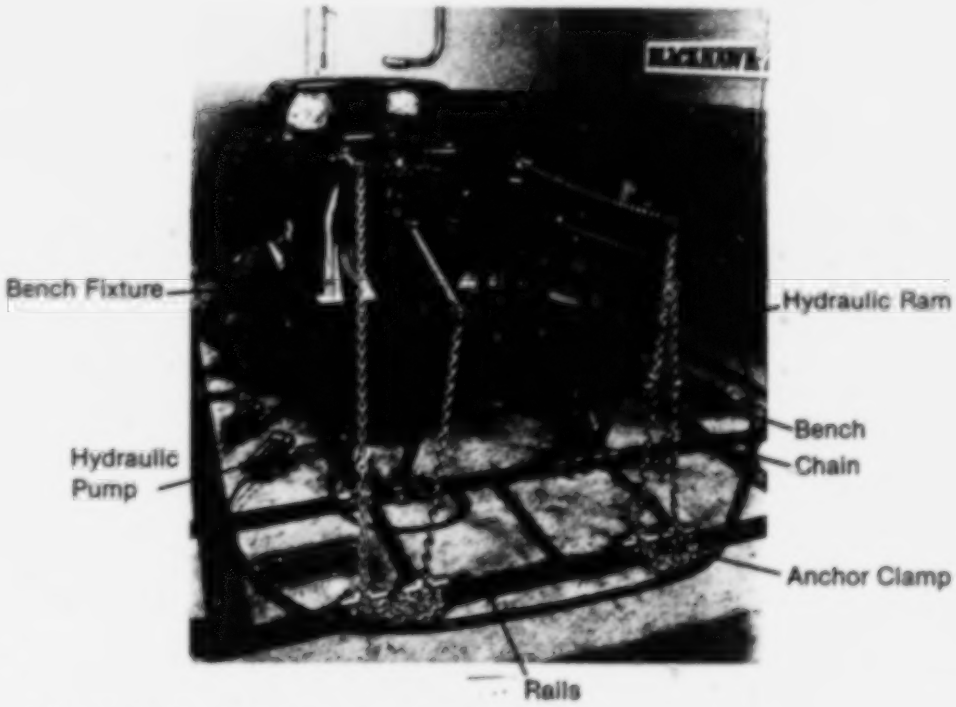
C. Floor anchor — For fastening anchors and pulling/pushing equipment

D. Frame clamp — For straightening frame damage on unibody vehicles and other designs with pinch welds in the center section

INFORMATION SHEET

V. Major parts of a bench used in combination with a rail frame straightener (Figure 5)

FIGURE 5



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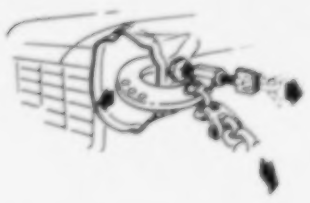
VI. Types of clamps and hooks used in frame alignment (Figures 6-17)

(NOTE: Frame straightening equipment is specially designed and made from high-strength metals. Do not use low-grade materials, especially in chains.)

A. Clamps

1. C clamp

FIGURE 6

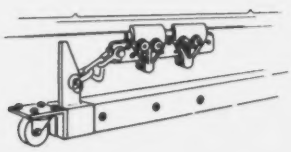


Figures 6-16 copyright Guy-Chart Tools, Inc.

INFORMATION SHEET

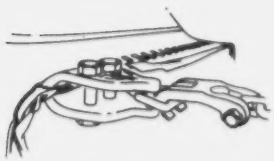
2. Rack clamp

FIGURE 7



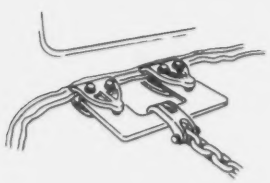
3. Single-scott clamp

FIGURE 8



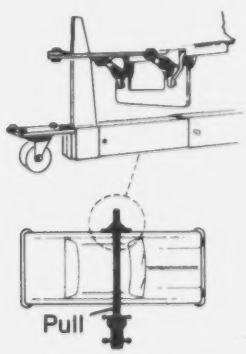
4. Double-scott clamp

FIGURE 9



5. Double-scott clamp with bar

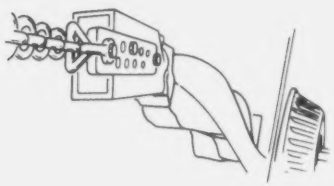
FIGURE 10



INFORMATION SHEET

6. Drawbar

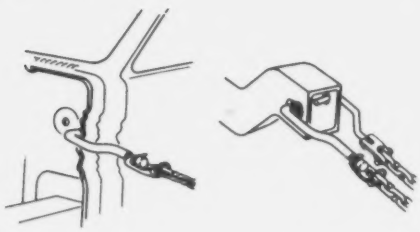
FIGURE 11



B. Hooks

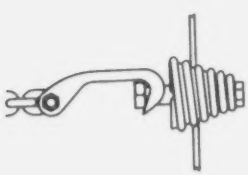
1. Finger hooks

FIGURE 12



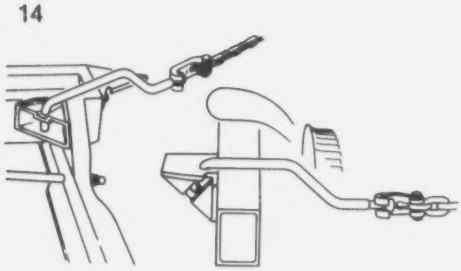
2. Spiral screw

FIGURE 13



3. Wedge tip

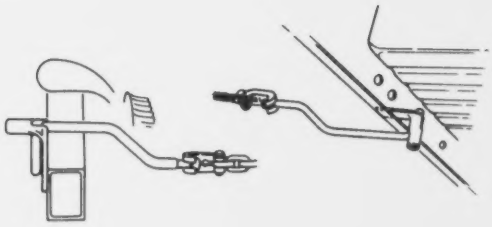
FIGURE 14



INFORMATION SHEET

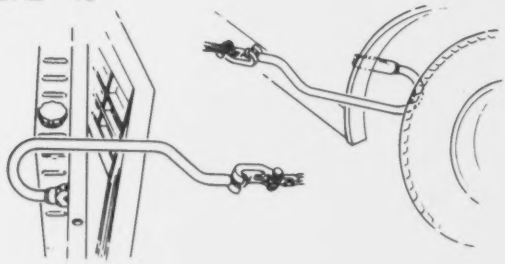
4. Hook extension

FIGURE 15



5. Utility tip and extension wedge

FIGURE 16



6. Plug hook

FIGURE 17

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VII. Safety rules to observe when using frame alignment equipment

A. Follow manufacturer's recommendations for attaching and operating equipment

B. Make sure that hook ups are securely made

C. Use only enough pressure to do the job

D. Stop pulls/pushes frequently and check equipment

E. Do not use defective chains or other equipment

INFORMATION SHEET

F. Avoid damaging hydraulic hoses

G. Do not stand in line with the pull and do not allow any one else to do so

H. Keep hands and body well clear of attachments and equipment during pulling/pushing operations

I. Make sure that vehicle is securely anchored before making any pulls/pushes

J. Cover chains or use a second safety chain

K. Use only recommended chains and other equipment

VIII. Guidelines for aligning frames

A. Follow equipment manufacturer's instructions

B. Carefully analyze damage and plan alignment procedures

C. Leave as much gauging equipment in place during alignment as possible

D. Remove only enough vehicle parts as are necessary to make proper hook ups

E. Make slow, low-pressure pulls

F. Check progress frequently and change pulls and hook ups as required for changes in alignment

G. Distribute pressure over as large an area of damage as possible

H. Use heat if necessary to straighten mild steel; do not heat beyond a cherry red color

I. Heat HSS or HSLA metals only in accordance with manufacturer's recommendations; if in doubt about the metal, do not heat

(NOTE: Use heat indicators such as crayons to monitor temperatures.)

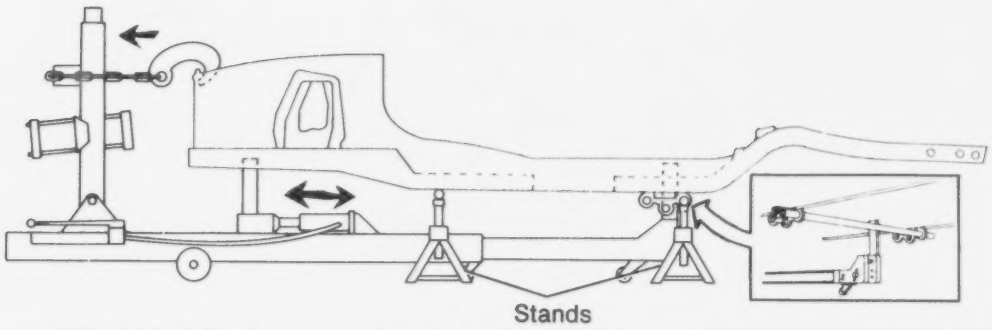
INFORMATION SHEET

IX. Types of pulls used in frame alignment (Figures 18-26)

(NOTE: The pressure applications shown below represent the general methods for frame alignment. The exact hook up and pressure application will vary with the type and extent of damage, the vehicle involved, and the type of equipment being used.)

A. Straight pull

FIGURE 18



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B. Downward pull

FIGURE 19

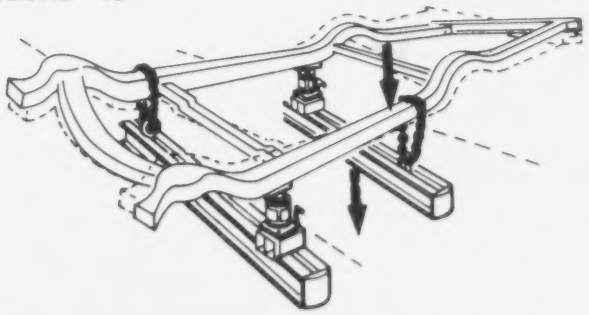

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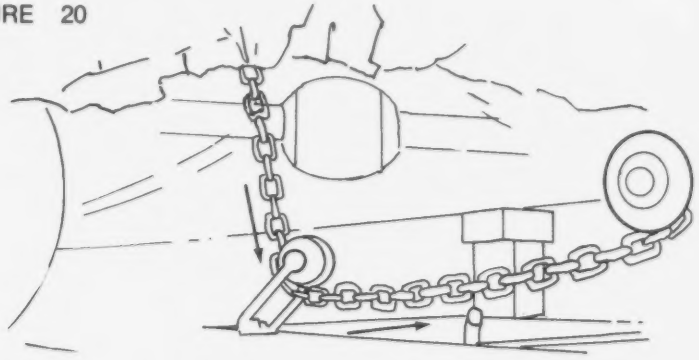
FIGURE 20



INFORMATION SHEET

C. Upward pull

FIGURE 21

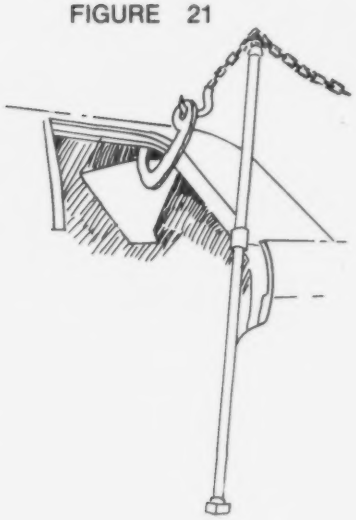
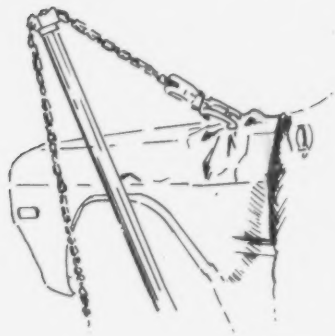
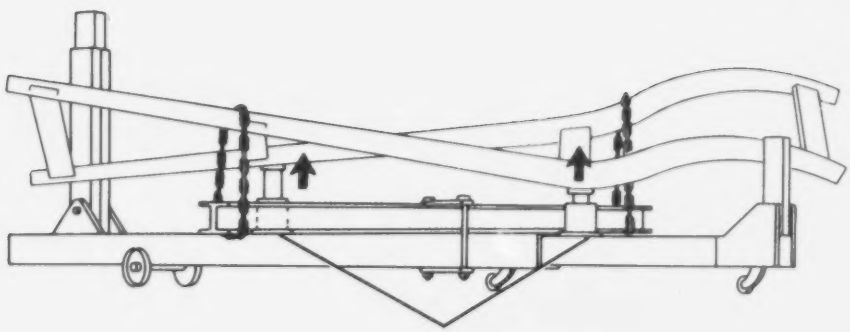


FIGURE 22



D. Push

FIGURE 23



Jacks

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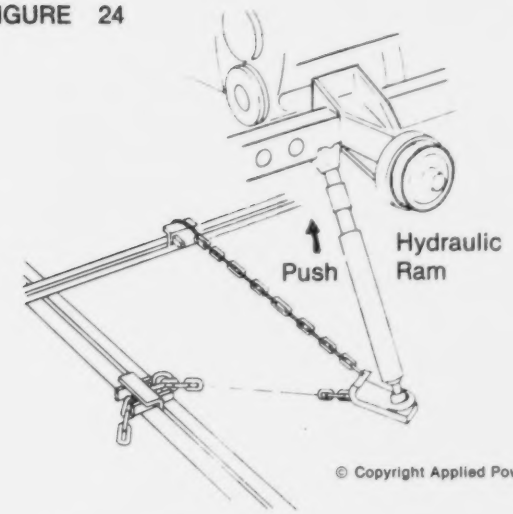
INFORMATION SHEET

FIGURE 24



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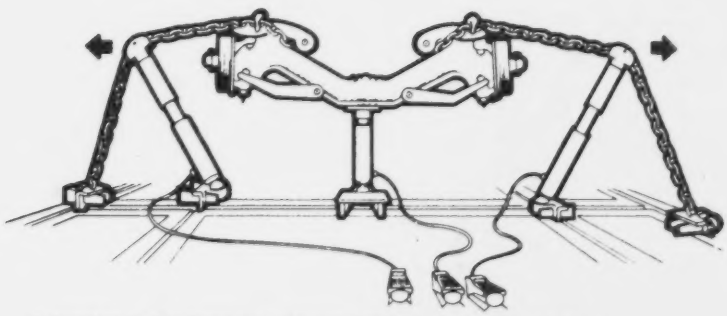
E. Opposing pulls

FIGURE 25



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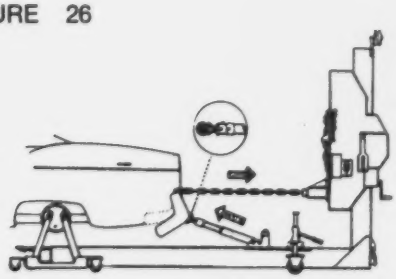
F. Combination pulls or pulls and pushes

FIGURE 26



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ALIGN FRAME
UNIT II

ASSIGNMENT SHEET #1 — PLAN REPAIR SEQUENCE

NAME _____ SCORE _____

Every case of damage to a vehicle is unique. It is a puzzle for the technician to solve. First, the technician must be a detective, who examines the vehicle to determine the extent of the damage and to figure out how it probably happened. Then the technician must apply his or her skills in determining a correct and efficient way to restore the vehicle to its original shape.

Study the vehicles shown below and the reports of their damage. Then describe how you would go about repairing them. Tell the order in which you would make the repairs. Assume that none of the vehicles have been totaled.

A. 1986 Chrysler Fifth Avenue — Hit from the side; has double sidesway in the center section; notice the uneven gap in the hood seam andthe bulge in the side just behind the cowl area; note the buckle in the roof away from the impact area.

_____

_____

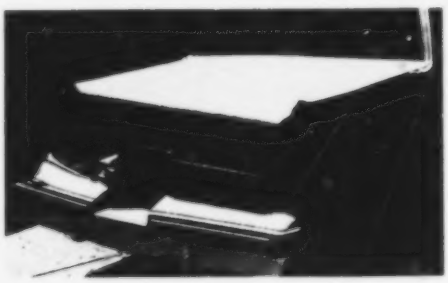
_____

_____

_____

ASSIGNMENT SHEET #1

B. 1985 Oldsmobile Cutlass — Impact in rear quarter panel on driver's side; shows sidesway in rear section (note buckles on passenger side rear quarter panel); shows downward mash at impacted corner.



ASSIGNMENT SHEET #1

C. 1986 Ford Escort GT — Impact at front corner on driver's side; twist in stub frame with sidesway; notice how high front quarter panel is raised on driver's side; driver's side frame horn in smashed inward in addition to the sidesway.

ALIGN FRAME
UNIT II

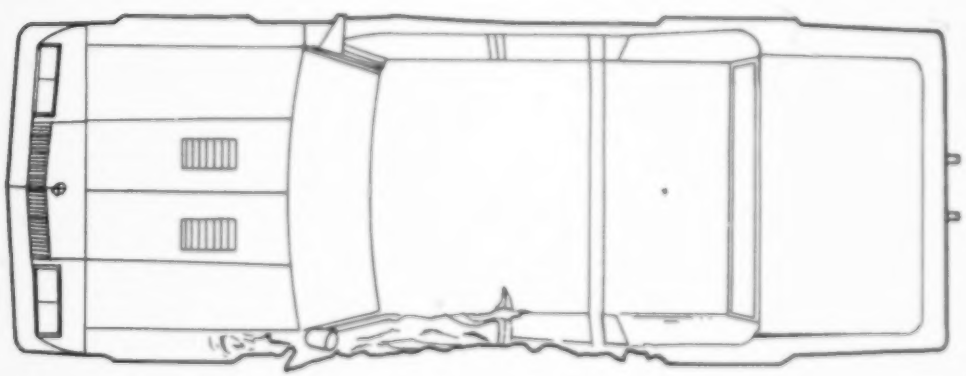
ASSIGNMENT SHEET #2 — USE SPECIFICATION GUIDE TO DETERMINE PROPER HOOK-UP POINTS

NAME _____ SCORE _____

To make efficient and proper repairs, the technician must know how to use repair equipment and reference guides. One of the major concerns in doing frame repair is that the vehicle is properly anchored and that pressure is applied in such a way that it does not increase the damage.

Review the vehicles and damage discussed in Assignment Sheet #1 and then use the drawings below to describe how you would hook up the vehicle to make the required repairs. For each type of damage, tell the type of frame straightening equipment that you would use. On the drawings indicate how you would anchor the vehicle and attach straightening equipment. Use labels or different colors to show hook-ups for each type of damage if more than one set up is required.

A. 1986 Chrysler Fifth Avenue



Equipment — _____

_____

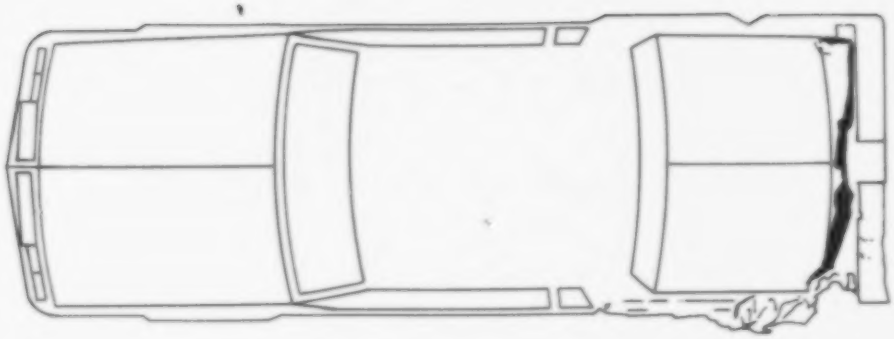
_____

_____

_____

ASSIGNMENT SHEET #2

B. 1985 Oldsmobile Cutlass



Equipment — _____

_____

_____

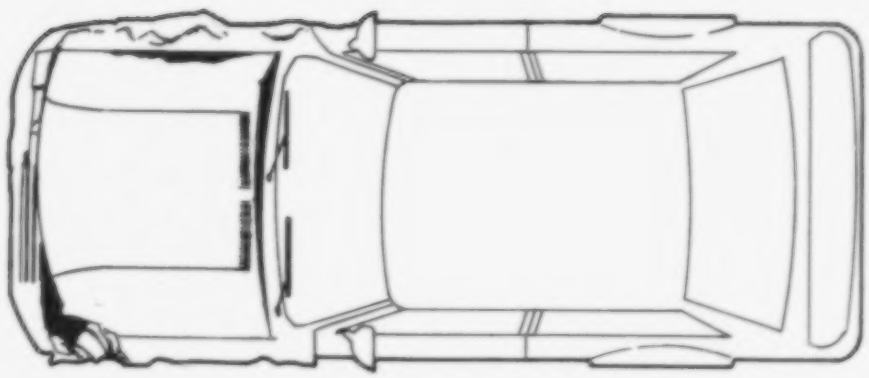
_____

_____

_____

ASSIGNMENT SHEET #2

C. 1986 Ford Escort GT



Equipment — _____

_____

_____

_____

_____

_____

ALIGN FRAME
UNIT II

ANSWERS TO ASSIGNMENT SHEETS

Evaluated to satisfaction of instructor

(NOTE: Procedures will vary with equipment used and some due to technician preferences. It is recommended that you thoroughly discuss Assignment Sheet #1 with the entire class before allowing students to complete Assignment Sheet #2 so that students will answer Assignment Sheet #2 using your preferred repair procedures.)

ALIGN FRAME
UNIT II

JOB SHEET #1 — INSPECT AND PERFORM ROUTINE MAINTENANCE ON HYDRAULIC EQUIPMENT

I. Equipment and materials

A. Hydraulic equipment

B. Operator's or maintenance manual for hydraulic equipment

C. Hand tools as required by procedure

D. Fluids and lubricants as required by procedure

II. Procedure

(NOTE: Your instructor will demonstrate the required maintenance procedures for your equipment.)

ALIGN FRAME
UNIT II

JOB SHEET #2 — PREPARE VEHICLE FOR FRAME ALIGNMENT

I. Equipment and materials

A. Damaged vehicle

B. Gauging equipment

C. Specification guide for vehicle

D. Alignment equipment

E. Operator's manual for alignment equipment

II. Procedure

A. Prepare vehicle for gauging and analysis

B. Gauge and analyze damage to the extent possible, leaving gauging equipment in place when practical

(NOTE: Follow the sequence recommended in Unit I.)

C. Plan repair sequence

1. Determine required pulls

2. Determine required hook-ups and locations

3. Determine order for making pulls

D. Remove any additional parts required to allow repair

E. Repair damage

(NOTE: Procedures for making repairs will be covered in the remaining job sheets in this unit.)

F. Repeat procedure for other types of damage

ALIGN FRAME
UNIT II

JOB SHEET #3 — ALIGN DIAMOND DAMAGE

I. Equipment and materials

A. Vehicle with diamond damage or simulator

B. Specification guide for vehicle

C. Gauging equipment

D. Frame straightening equipment

E. Operating instructions for straightening equipment

F. Torch or welding equipment

II. Procedure

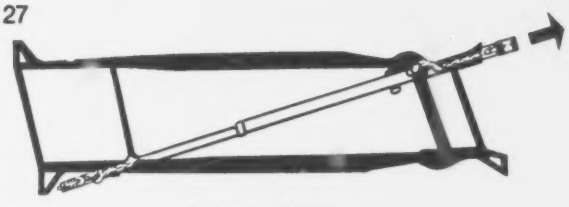
A. Prepare vehicle for alignment of diamond damage, including gauging and repair planning

B. Set up anchors, pulls, and blocking as required

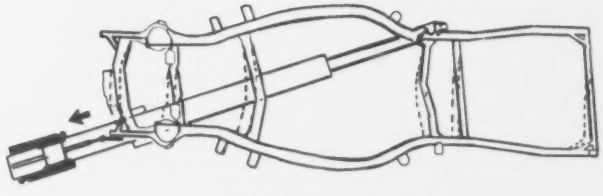
(NOTE: Because the required procedures will vary with the equipment, vehicle, and damage, your instructor will demonstrate the exact procedure. See examples below.)

1. Portable (Figure 27)

FIGURE 27



Ladder Frame

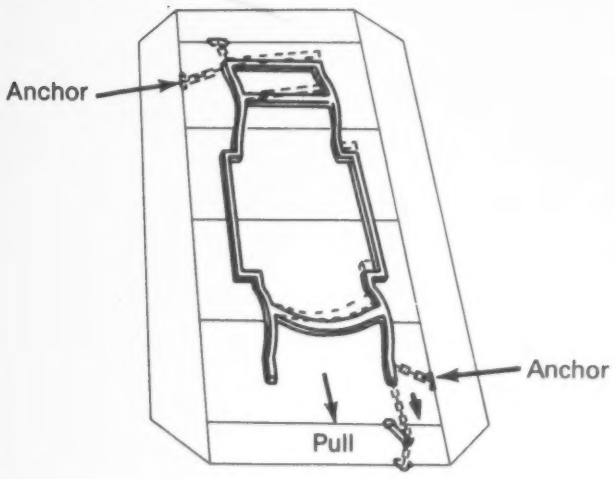


Perimeter Frame

JOB SHEET #3

2. Stationary (Figure 28)

FIGURE 28



C. Pull to correct alignment

D. Continue to next required repair or clean up work area and put away equipment

ALIGN FRAME
UNIT II

JOB SHEET #4 — ALIGN TWIST DAMAGE

I. Equipment and materials

A. Vehicle with twist damage or simulator

B. Specification guide for vehicle

C. Gauging equipment

D. Frame straightening equipment

E. Operating instructions for straightening equipment

F. Torch or welding equipment

II. Procedure

A. Prepare vehicle for alignment of twist damage, including gauging and repair planning

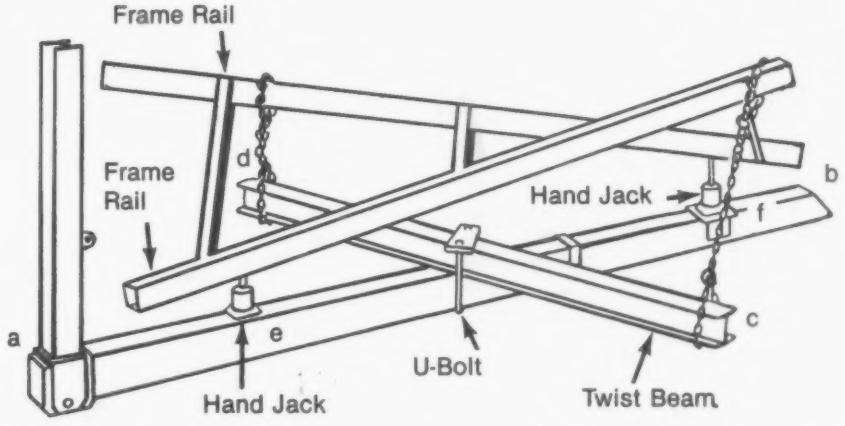
B. Set up anchors, pulls, and blocking as required

(NOTE: Because the required procedures will vary with the equipment, vehicle, and damage, your instructor will demonstrate the exact procedure. See examples below.)

EXAMPLES:

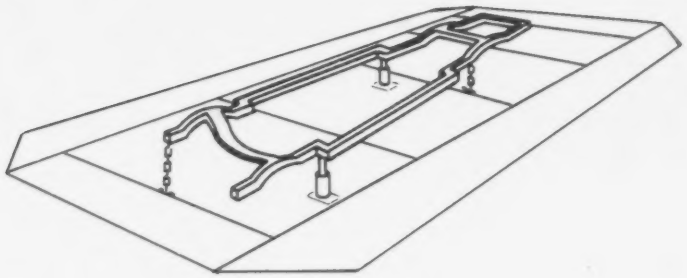
(NOTE: Twist is corrected by pushing and pulling opposite corners of the frame.)

FIGURE 29 (Portable unit)



JOB SHEET #4

FIGURE 30 (Stationary unit)



C. Pull to correct alignment

D. Continue to next required repair or clean up work area and put away equipment

ALIGN FRAME
UNIT II

JOB SHEET #5 — ALIGN SIDESWAY DAMAGE

I. Equipment and materials

A. Vehicle with sidesway damage or simulator

B. Specification guide for vehicle

C. Gauging equipment

D. Frame straightening equipment

E. Operating instructions for straightening equipment

F. Torch or welding equipment

II. Procedure

A. Prepare vehicle for alignment of sidesway, including gauging and repair planning

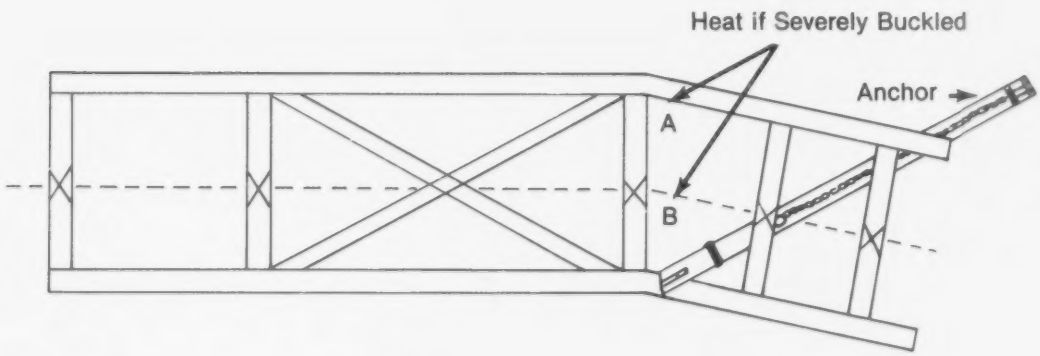
B. Set up anchors, pulls, and blocking as required

(NOTE: Because the required procedures will vary with the equipment, vehicle, and damage, your instructor will demonstrate the exact procedure. See examples below.)

EXAMPLES:

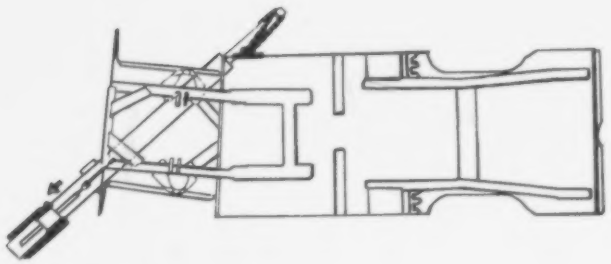
FIGURE 31 (Portable equipment)

1. Front or rear sidesway in conventional frame



JOB SHEET #5

2. Front sidesway in unitized body



3. Center sidesway

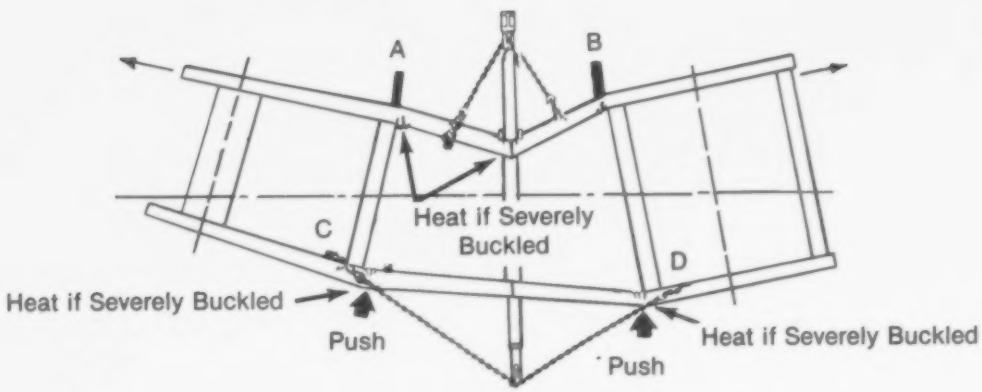
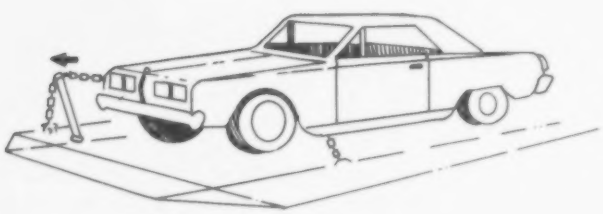


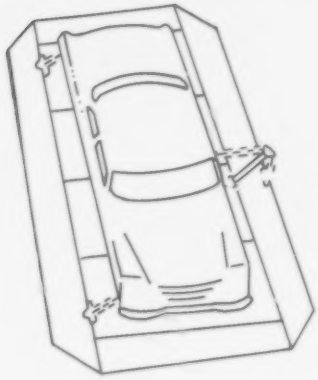
FIGURE 32 (Stationary equipment)

1. Front sidesway



JOB SHEET #5

2. Center sidesway



C. Pull to correct alignment

D. Continue to next required repair or clean up work area and put away equipment

ALIGN FRAME
UNIT II

JOB SHEET #6 — ALIGN SAG DAMAGE

I. Equipment and materials

A. Vehicle with sag damage or simulator

B. Specification guide for vehicle

C. Gauging equipment

D. Frame straightening equipment

E. Operating instructions for straightening equipment

F. Torch or welding equipment

II. Procedure

A. Prepare vehicle for alignment of sag, including gauging and repair planning

B. Set up anchors, pulls, and blocking as required

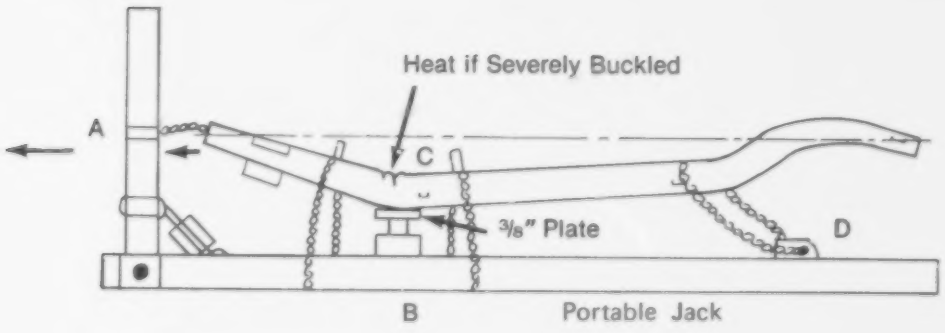
(NOTE: Because the required procedures will vary with the equipment, vehicle, and damage, your instructor will demonstrate the exact procedure. See examples below.)

EXAMPLES:

(NOTE: If possible, correct both rails at once. Otherwise, alternate between rails, correcting a little damage at a time.)

FIGURE 33 (Portable equipment)

1. Conventional frame



JOB SHEET #6

2. Unitized body

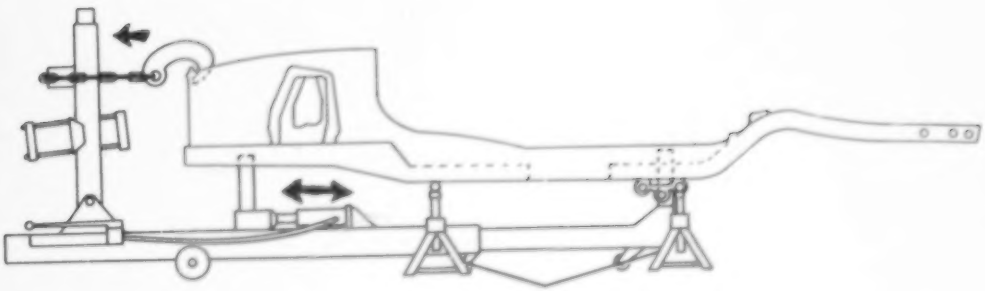
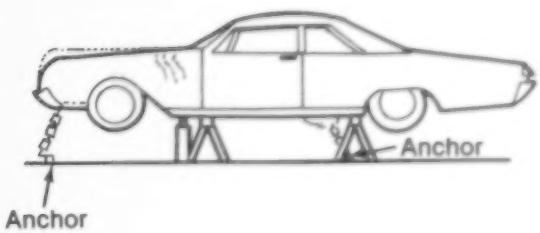


FIGURE 34 (Stationary equipment)



C. Pull to correct alignment

D. Continue to next required repair or clean up work area and put away equipment

ALIGN FRAME
UNIT II

JOB SHEET #7 — ALIGN MASH DAMAGE

I. Equipment and materials

A. Vehicle with mash damage or simulator

B. Specification guide for vehicle

C. Gauging equipment

D. Frame straightening equipment

E. Operating instructions for straightening equipment

F. Torch or welding equipment

II. Procedure

A. Prepare vehicle for alignment of mash, including gauging and repair planning

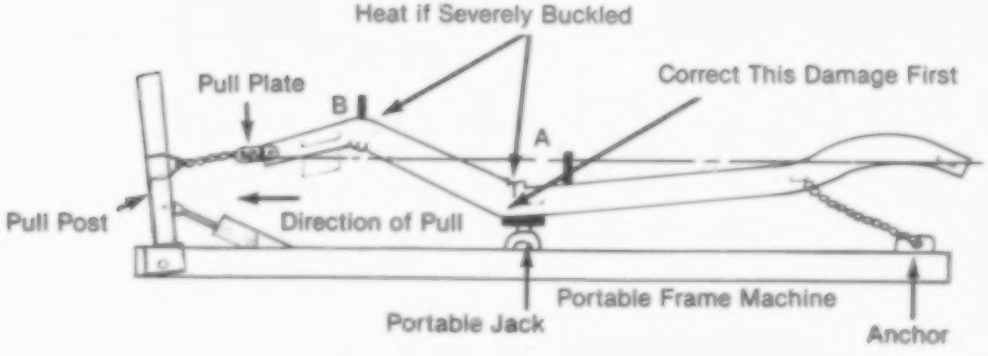
B. Set up anchors, pulls, and blocking as required

(NOTE: Because the required procedures will vary with the equipment, vehicle, and damage, your instructor will demonstrate the exact procedure. See examples below.)

EXAMPLES:

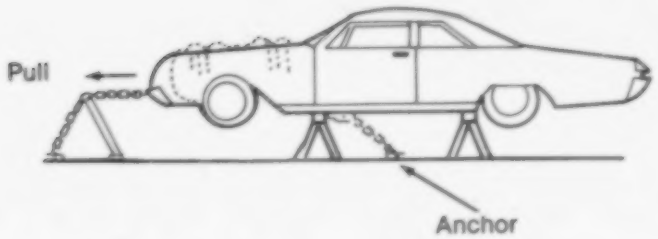
(NOTE: Mash will often lead to more than one buckle in the rail. Begin repairs at the buckle nearest the center of the vehicle and work out toward the end. If possible, repair both rails at one time. Otherwise, alternate between rails, correcting a little damage at a time.)

FIGURE 35 (Portable equipment)



JOB SHEET #7

FIGURE 36 (Stationary equipment)



C. Pull to correct alignment

D. Continue to next required repair or clean up work area and put away equipment

ALIGN FRAME
UNIT II

TEST

NAME _____ SCORE _____

1. Match to their correct definitions terms associated with frame alignment. Write the number of the term in the blank beside the correct definition.

_____a. The side rails of the frame system which are tied together with cross members and braces to form the frame of a vehicle

_____b. That portion of the frame ahead of the front cross member where the bumper system attaches to the frame

_____c. Frame sections used to tie the two frame rails together to form the frame

_____d. Two flanges welded together along their edges; type of construction found where the rocker panel welds to the floor pan

_____e. Frame straightening unit that can be moved from vehicle to vehicle to straighten the frame and body

_____f. Frame straightening system that is stationary and the vehicle must be placed on it for frame body straightening purposes

_____g. Type of frame clamp where increased pressure makes the jaws of the clamp pull taut on the metal

_____h. Type of clamp used to anchor along pinch welds

_____i. A plate used to bolt to the frame, providing a pull location where one is not available in the frame

_____j. Tie down points to hold the vehicle when using frame straightening units

_____k. Performing several pulls at the same time

_____l. Several types of frame damage occurring at the same time

_____m. Strengthening a frame by welding a plate or rail to it

1. Frame horn
2. Fishplating
3. Portable frame unit
4. Anchor
5. Pull plate
6. Frame rail
7. Pinch weld
8. Multiple hook up
9. Combination damage
10. Cross member
11. Under body clamp
12. Stationary frame unit
13. Self-tightening clamp

TEST

2. List the major actions performed during frame alignment. Write your answers in the spaces below.

   a. _____

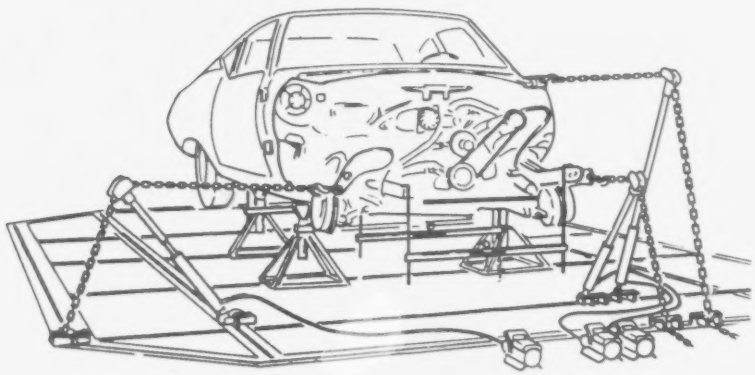
   b. _____

   c. _____

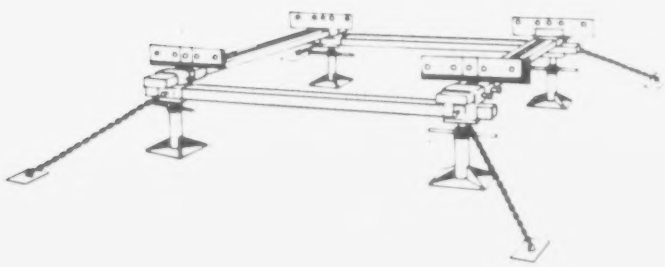
3. Identify types of frame straighteners. Write the correct name in the space provided with each illustration.

Portable
Stationary
Floor anchor
Frame clamp

a. _____

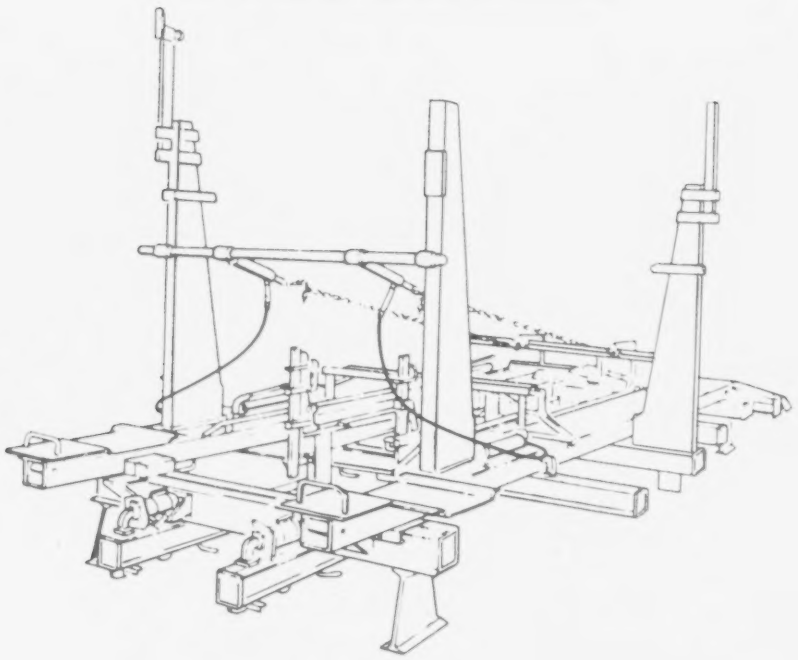


b. _____

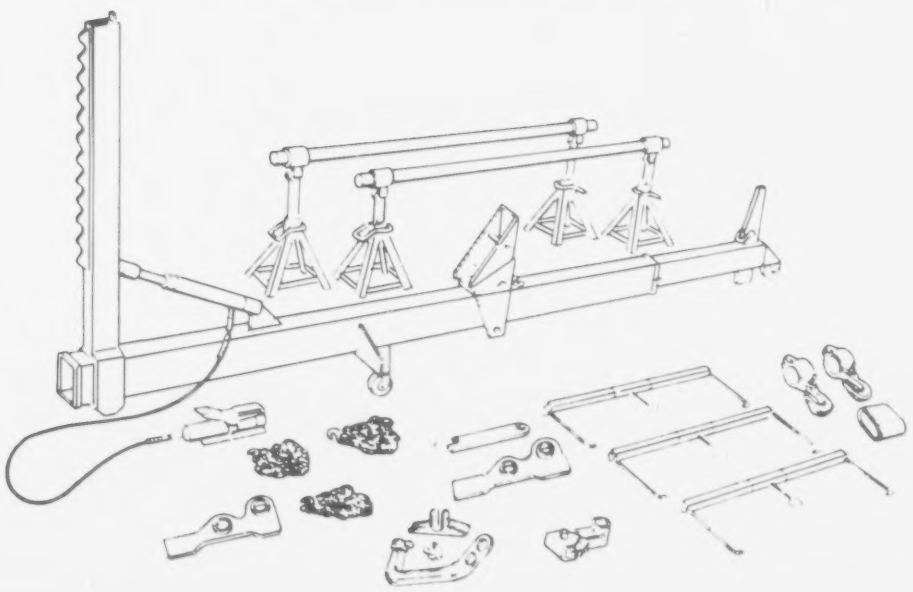


TEST

c. _____



d. _____



TEST

4. Match types of frame straighteners to their correct uses. Write the number of the frame straightener in the space beside its correct use.

_____a. For straightening limited frame damage areas where few hook ups are required	1. Stationary
_____b. For straightening any type of frame damage on any size of conventional vehicle	2. Frame clamp
_____c. For fastening anchors and pulling/pushing equipment	3. Floor anchor
_____d. For straightening frame damage on unibody vehicles and other designs with pinch welds in the center section	4. Portable

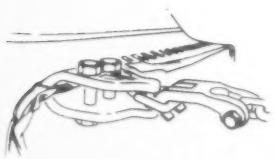
5. Label the major parts of a bench used in combination with a floor rail frame straightener. Write the correct name of each part in the spaces provided.

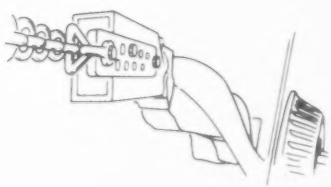
TEST

6. Identify types of clamps and hooks used in frame alignment. Write the correct names in the spaces provided.

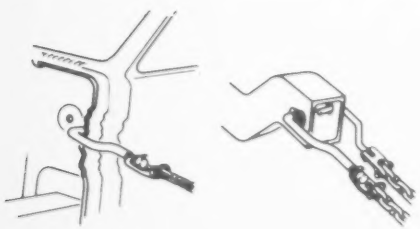
C clamp	**Drawbar**	**Wedge tip**
Rack clamp	**Plug hook**	**Hook extension**
Single-scott clamp	**Finger hook**	**Utility tip and extension wedge**
Double-scott clamp	**Spiral screw hook**	
Double-scott clamp with bar		

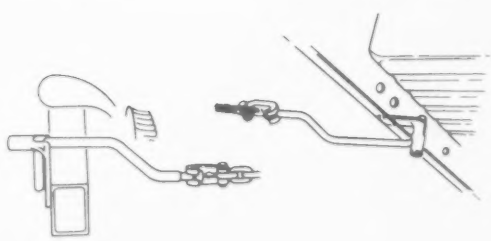
a. _____ b. _____



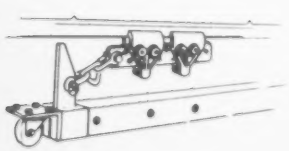


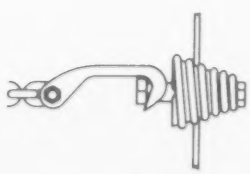
c. _____ d. _____





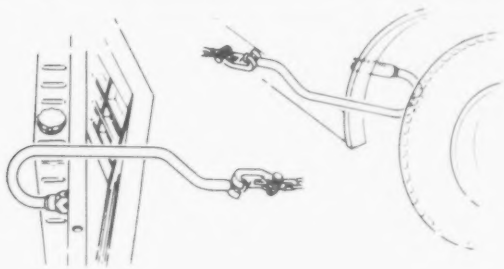
e. _____ f. _____

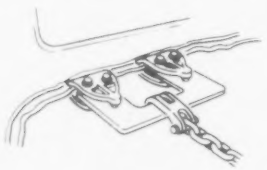




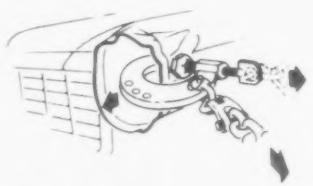
TEST

g. _____ h. _____

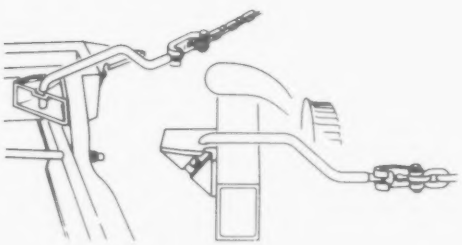


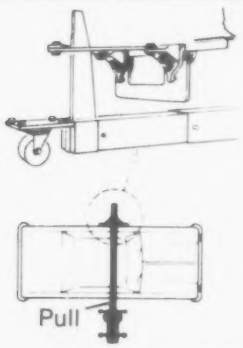


i. _____ j. _____



k. _____ l. _____





7. State seven safety rules to observe when using frame alignment equipment. Write your answers in the space provided.

a. _____

_____

b. _____

_____

TEST

c. _____

_____

d. _____

_____

e. _____

_____

f. _____

_____

g. _____

_____

8. Select from a list guidelines for the operation of frame alignment equipment. Write an "X" in the space beside each correct guideline below.

_____a. Follow equipment manufacturer's instructions

_____b. Carefully analyze damage and plan alignment procedure

_____c. Remove gauging equipment before performing alignment

_____d. Remove all vehicle parts that attach to frame so that anchors can be placed completely around frame

_____e. Make slow, low-pressure pulls

_____f. Check progress frequently and change pulls and hook ups as required for changes in alignment

_____g. Concentrate pressure in a small area to increase effectiveness

_____h. Use heat if necessary to straighten mild steel; do not heat beyond cherry red

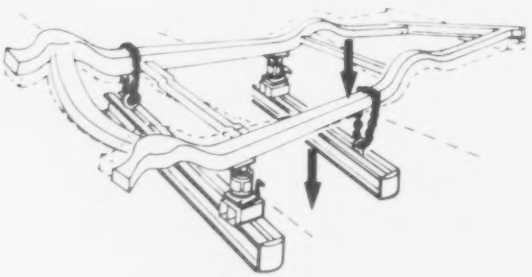
_____i. Heat HSS and HSLA metals only in accordance with manufacturer's recommendations; if in doubt about the metal, do not heat

TEST

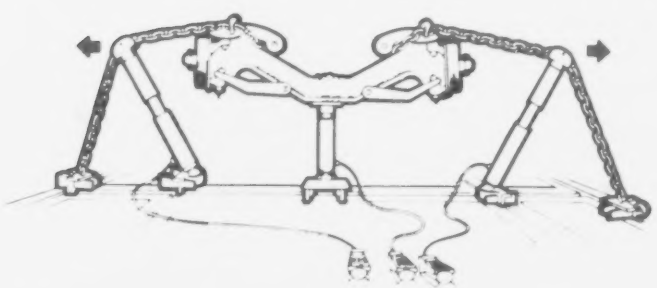
9. Identify types of pulls used in frame alignment. Write the correct term for each pull shown in the space provided.

Straight pull
Downward pull
Upward pull
Push
Opposing pulls
Combination pulls or pulls and pushes

a. _____

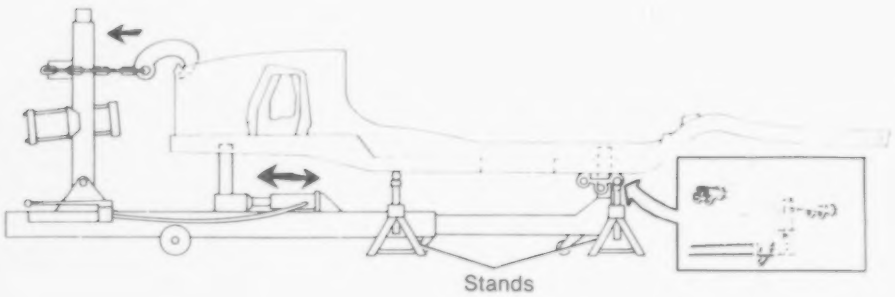


b. _____

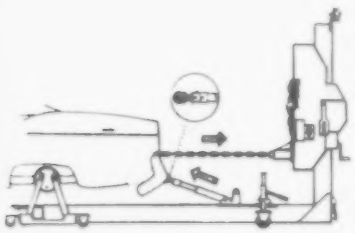


TEST

c. _____

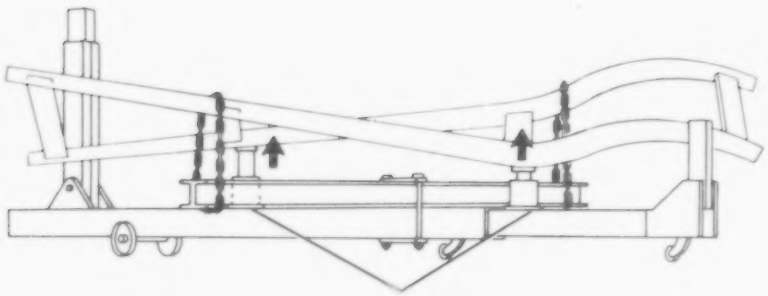


d. _____



TEST

e. _____



Jacks

(NOTE: Test items 10, 11, and 12 list the assignment sheets and the job sheets. The are an important part of this test. If they have not been completed, check with your instructor.)

10. Plan repair sequence.

11. Use specification guide to determine proper hook-up points.

12. Demonstrate the ability to

    a. Inspect and performance routine maintenance on hydraulic equipment.

    b. Prepare vehicle for frame alignment.

    c. Align diamond damage.

    d. Align twist damage.

    e. Align sidesway damage.

    f. Align sag damage.

    g. Align mash damage.

ALIGN FRAME
UNIT II

ANSWERS TO TEST

1. a. 6
   b. 1
   c. 10
   d. 7
   e. 3
   f. 12
   g. 13
   h. 11
   i. 5
   j. 4
   k. 8
   l. 9
   m. 2

2. a. Anchoring
   b. Blocking
   c. Pulling/pushing

3. a. Floor anchor
   b. Frame clamp
   c. Stationary
   d. Portable

4. a. 4
   b. 1
   c. 3
   d. 2

5. a. Hydraulic rams
   b. Bench
   c. Chain
   d. Anchor clamp
   e. Rails
   f. Hydraulic pump
   g. Bench fixture

6. a. Single-scott clamp
   b. Drawbar
   c. Finger hook
   d. Hook extension
   e. Rack clamp
   f. Spiral screw hook
   g. Utility tip and extension wedge
   h. Double-scott clamp
   i. Plug hook
   j. C clamp
   k. Wedge tip
   l. Double-scott clamp with bar

7. (Answer should include any seven of the following.)

   a. Follow manufacturer's recommendations for attaching and operating equipment
   b. Make sure that hook ups are securely made
   c. Use only enough pressure to do the job
   d. Stop pulls/pushes frequently and check equipment
   e. Do not use defective chains or other equipment
   f. Avoid damaging hydraulic hoses
   g. Do not stand in line with the pull and do not allow any one else to do so
   h. Keep hands and body well clear of attachments and equipment during pulling/pushing operations
   i. Make sure that vehicle is securely anchored before making any pulls/pushes
   j. Cover chains or use a second safety chain
   k. Use only recommended chains and other equipment

ANSWERS TO TEST

8. a, b, e, f, h, i

9. a. Downward pull
   b. Opposing pulls
   c. Straight pull
   d. Combination pulls or pulls and pushes
   e. Push

10. Evaluated to the satisfaction of the instructor.

11. Evaluated to the satisfaction of the instructor.

12. Performance skills evaluated to the satisfaction of the instructor.

ALIGN SUSPENSION AND STEERING COMPONENTS
UNIT III

UNIT OBJECTIVE

After completing this unit, the student should be able to determine and perform alignment requirements for various designs of suspension systems. The student will show this ability by completing unit test and job sheets with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match to their correct definitions terms associated with suspension and steering alignment.
2. Identify types of suspension systems.
3. Label parts of a suspension system.
4. Label parts of a MacPherson-type strut assembly.
5. List factors that affect suspension alignment.
6. Match elements of front-end geometry to their correct descriptions.
7. Distinguish among elements of front-end geometry by whether they can be adjusted.
8. Label types of steering systems.
9. Demonstrate the ability to
   a. Gauge a strut tower.
   b. Remove and replace a MacPherson-type strut.
   c. Align suspension and steering components.

ALIGN SUSPENSION AND STEERING COMPONENTS
UNIT III

SUGGESTED ACTIVITIES

I. Unit contents

A. Objective sheet

B. Suggested activities

C. Transparency masters

1. TM #1 — Parts of a Suspension System
2. TM #2 — Overlay for Parts of a Suspension System
3. TM #3 — Parts of a MacPherson Strut
4. TM #4 — Overlay for Parts of a MacPherson Strut
5. TM #5 — Front-end Geometry—Front View
6. TM #6 — Front-end Geometry—Camber Overlay
7. TM #7 — Front-end Geometry—SAI Overlay
8. TM #8 — Front-end Geometry—Included Angle
9. TM #9 — Caster
10. TM #10 — Toe-In and Toe-Out
11. TM #11 — Turning Radius and Tracking
12. TM #12 — Pitman Arm Steering
13. TM #13 — Rack-and-Pinion Steering

D. Information sheet

E. Job sheets

1. Job Sheet #1 — Gauge a Strut Tower
2. Job Sheet #2 — Remove and Replace a MacPherson-Type Strut
3. Job Sheet #3 — Align Suspension and Steering Components

F. Unit test

G. Answers to test

SUGGESTED ACTIVITIES

II. Instructor's guide

A. Review unit and plan presentation.

B. Obtain materials necessary to supplement unit.

1. Media

(NOTE: The programs listed below are available from Teaching Aids Incorporated, Post Office Box 1798, Costa Mesa, California 92628-0798. The first program is also available from Bergwall Productions, Inc., Post Office Box 238, Garden City, New York 11530-0238.)

a. *The Front End Explained*

(NOTE: This award-winning package contains four separate programs: *Basic Parts and Principles, Problems — Causes and Corrections, How to Replace a Lower Ball Joint,* and *Alignment and Adjustments.*

b. *Steering Geometry*

(NOTE: This program discusses front-end geometry as it relates to caster, camber, steering axis inclination, toe, and turning radius.)

c. *The GM MacPherson Strut System*

(NOTE: This package contains three programs covering service of a General Motors MacPherson strut system: *Removing and Disassembling, Assembling and Replacing,* and *Aligning the Front End.*)

2. Transparencies

a. *Suspensions, Steering, and Alignment*

(NOTE: Teaching Aids Incorporated offers a package of 17 transparencies with 16 overlays on suspension and steering systems as well as wheel alignment. These are available from the address above.)

b. *Auto Body: Frame Repairer*

(NOTE: Transparencies for this manual are available from the State Department of Vocational and Technical Education, Curriculum and Instructional Materials Center, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074.)

3. Competency profiles

(NOTE: Competency profiles for this manual are available from the Oklahoma State Department of Vocational and Technical Education at the address above.)

SUGGESTED ACTIVITIES

C. Provide students with unit.

D. Introduce unit.

SUGGESTIONS:

- Review the definition of *frame* learned in Unit I, emphasizing the fact that the frame rests on the wheels through the suspension system.
- Point out suspension and steering damage in actual vehicles.
- Use specification guides to discuss how suspension components are used in them.

E. Discuss unit and specific objectives.

SUGGESTIONS:

- Tie objectives to previously learned material.
- Point out how mastery of the specific objectives will lead to mastery of the unit objective.
- Invite shop owners or managers to talk to the class about how their shops handle front-end repairs—i.e., which ones they do, which ones they send out, the advantages of knowing repair procedures, etc.
- Reassure students who may be intimidated by the term *geometry* by explaining that geometry simply refers to alignments and angles similar to those they have already mastered.

F. Discuss information sheet.

1. Use Information Sheet, Section I to discuss terms associated with steering and suspension systems, using actual components.
2. Use Information Sheet, Section II to discuss types of suspension systems.

SUGGESTIONS:

- Use service manuals, wall charts, or actual vehicles to show examples of each type of suspension system.
- Point out those components of each type of system that might require repair.
- Show *The Front End Explained.*

SUGGESTED ACTIVITIES

3. Use Information Sheet, Section III and Transparencies #1 and #2 to discuss parts of a suspension system.

   SUGGESTIONS:

   - Use a removed suspension system or model to expand discussion.
   - Use Transparency #1 without overlay to quiz students on parts.
   - Show a variety of designs so that students can relate parts.

4. Use Information Sheet, Section IV and Transparencies #3 and #4 to discuss MacPherson-type struts.

   SUGGESTIONS:

   - Discuss the prevalence of MacPherson-type struts on today's smaller cars, especially those with front-wheel drive.
   - Demonstrate Job Sheet #1 and allow student practice; use a variety of vehicles.
   - Show *The GM MacPherson Strut System.*
   - Demonstrate Job Sheet #2 and allow student practice.

5. Use Information Sheet, Section V to discuss factors that affect suspension alignment, relating them to previous material, other objectives, and repair jobs.

6. Use Information Sheet, Sections VI and VII and Transparencies #5-#11 to discuss front-end geometry.

   SUGGESTIONS:

   - Show *Steering Geometry.*
   - Use a model or an unattached suspension system to demonstrate various adjustments and relationships.
   - Use service manuals and specification guides to point out specifications and procedures.

7. Use Information Sheet, Section VIII and Transparencies #12 and #13 to discuss steering systems.

   SUGGESTIONS:

   - Relate steering system components and alignment to front-end geometry, ride, and safety.
   - Show actual vehicle steering systems using a variety of designs.

SUGGESTED ACTIVITIES

G. Review unit.

H. Give test.

I. Critique test and discuss in class.

J. Reteach and retest as required.

K. Complete appropriate sections of competency profiles.

III. Unit references

A. Coghlan, David A. *Automotive Chassis Systems: Steering, Suspension, Alignment, and Brakes*, 2nd ed. Boston: Breton Publishers, a division of Wadsworth, Inc., 1985.

B. Crouse, William H., and Donald L. Anglin. *Automotive Body Repair and Refinishing*, 2nd ed. New York: McGraw-Hill Book Company/Gregg Division, 1986.

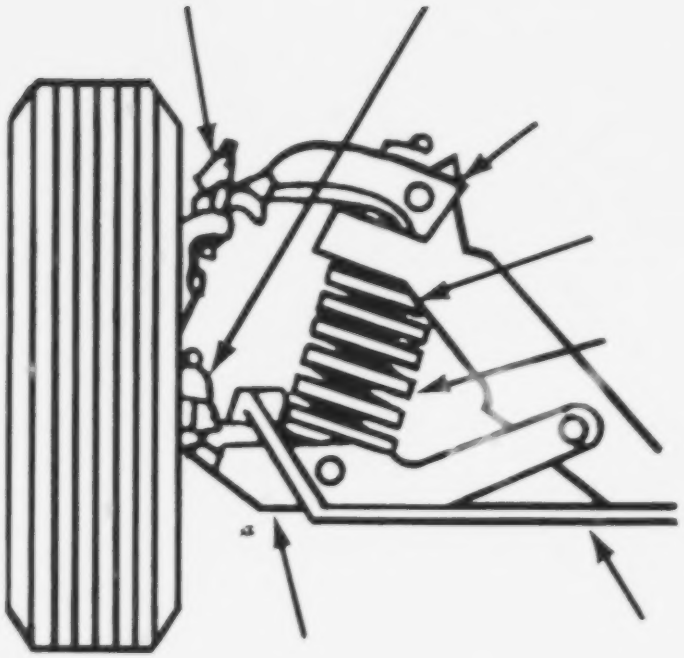
C. *Gauging and Analyzing Collision Damage*. Grand Island, Nebraska: Chief Automotive Systems, 1978.

D. Manual, Edward F., and Wayman R. Penner. *Auto Body Repair and Repainting*. Stillwater, Oklahoma: State Department of Vocational and Technical Education/ Curriculum and Instructional Materials Center, 1974.

E. *The New Science of Unibody Repair*. Milwaukee, Wisconsin: Blackhawk Applied Power, Inc., Automotive Division, 1982.

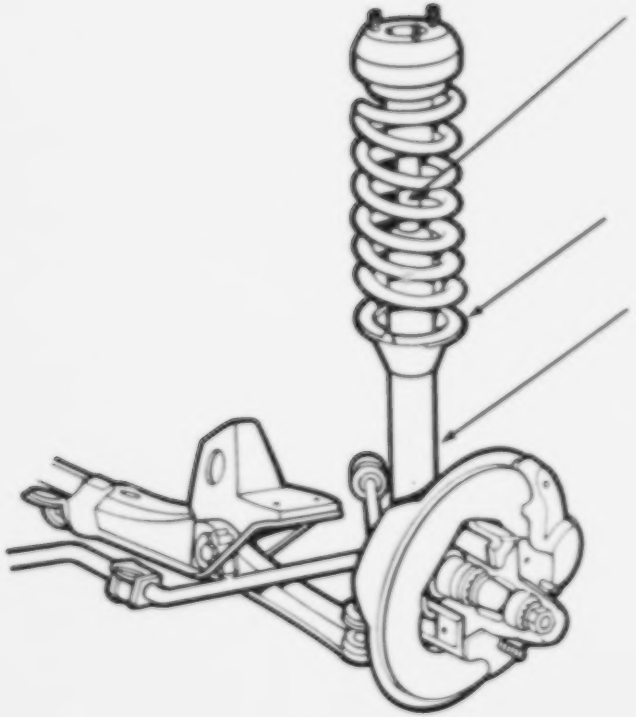
F. Rhone, L.C., and H. David Yates. *Total Auto Body Repair*. 2nd ed. Indianapolis: Bobbs-Merrill Educational Publishing, 1983.

Parts of a Suspension System



Upper
Ball
Joint
Lower
Ball
Joint
Upper Control Arm
Shock Absorber
Coil Spring
Stabilizer Bar
Lower
Control
Arm

Parts of a MacPherson Strut



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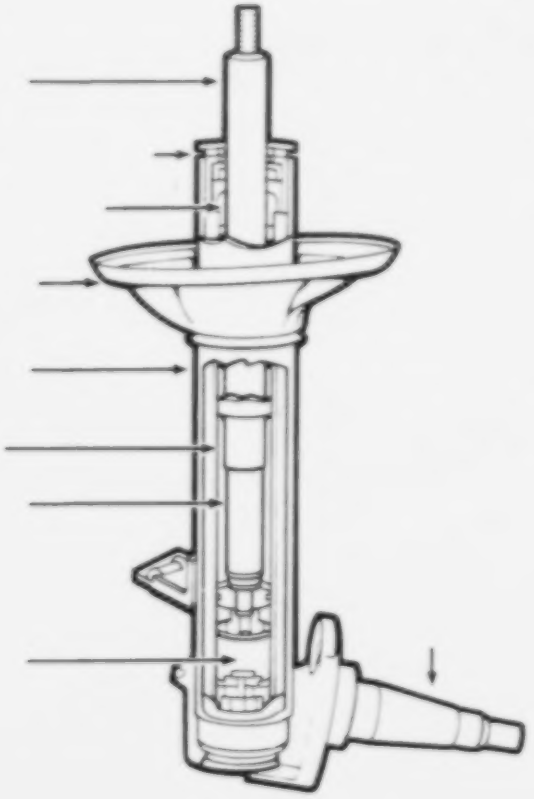

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Piston Rod

Ring Nut and Oil Seal

Piston Rod Guide

Spring Seat

Strut Tube

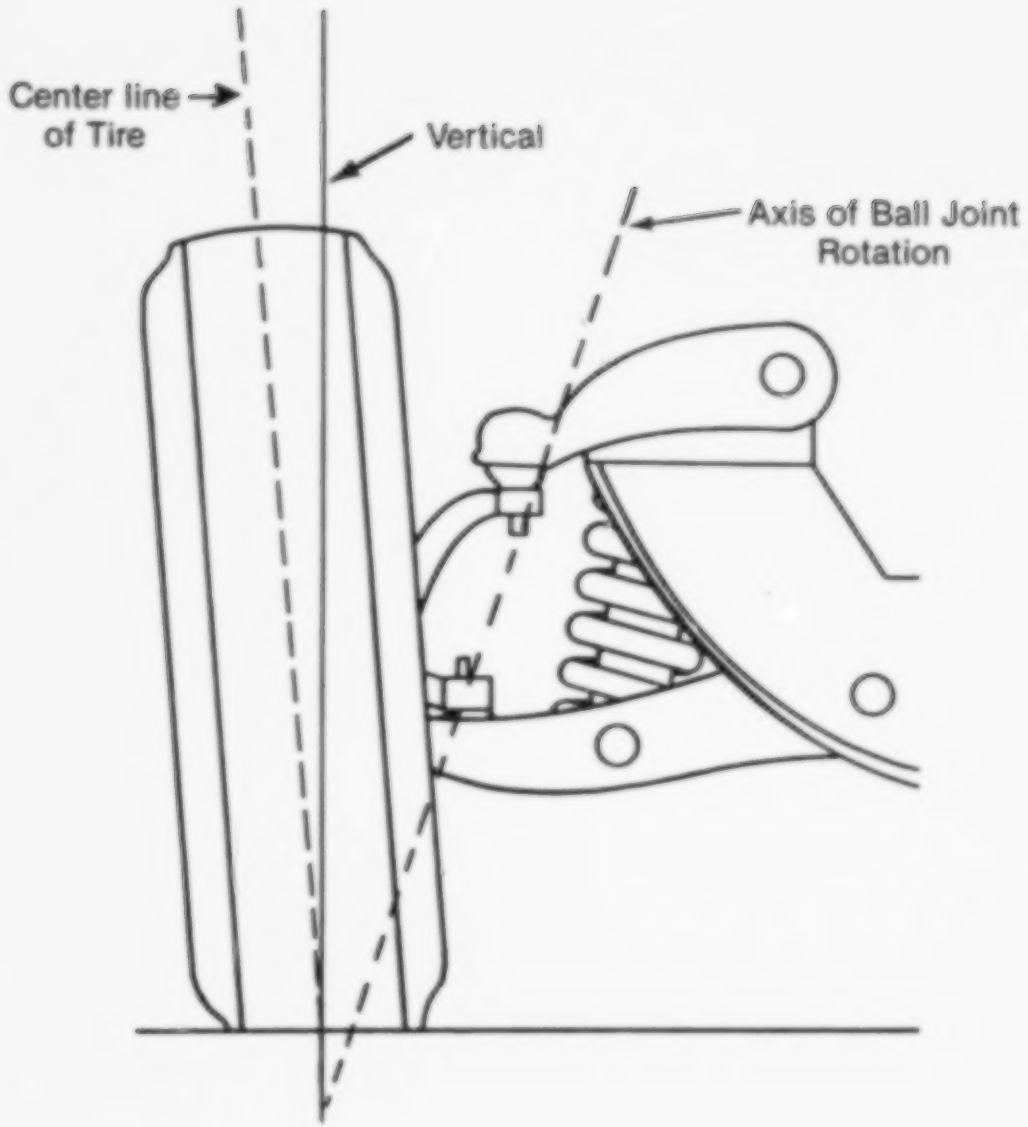
Cylinder

Piston Rod

Spindle

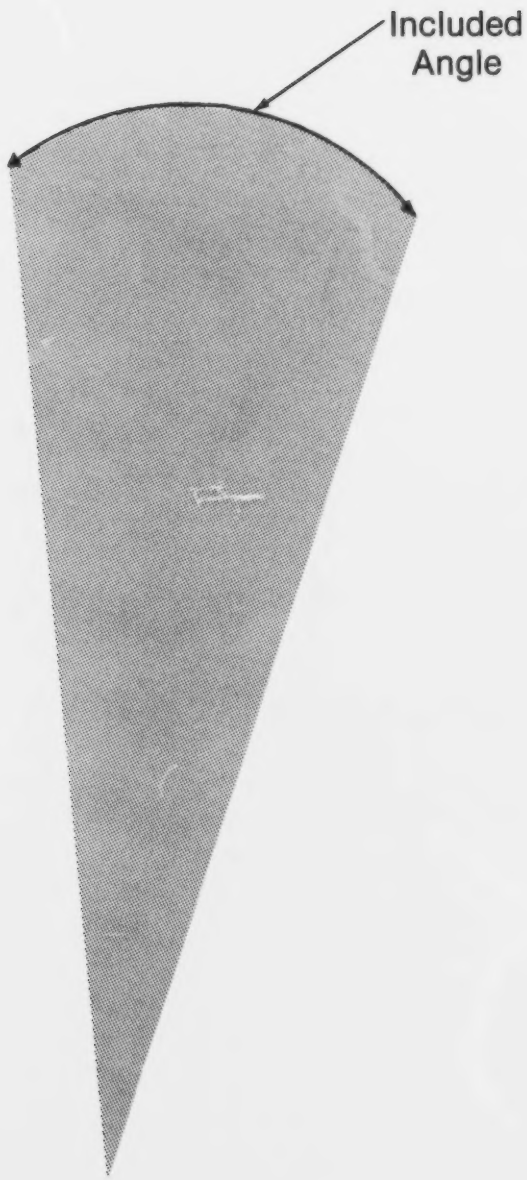
Base Valve

Front-End Geometry

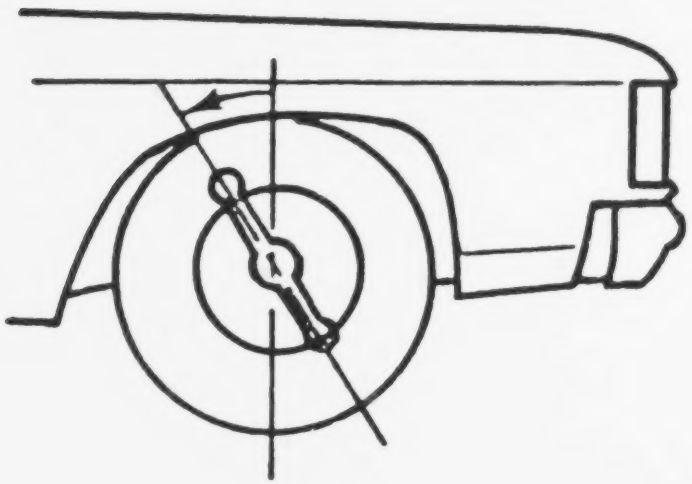


Camber
Angle

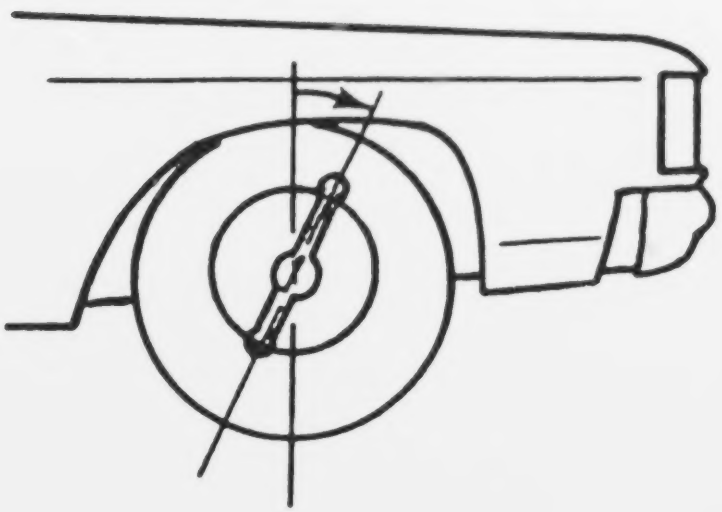
Steering Axis
Inclination (SAI)


Included
Angle

Caster

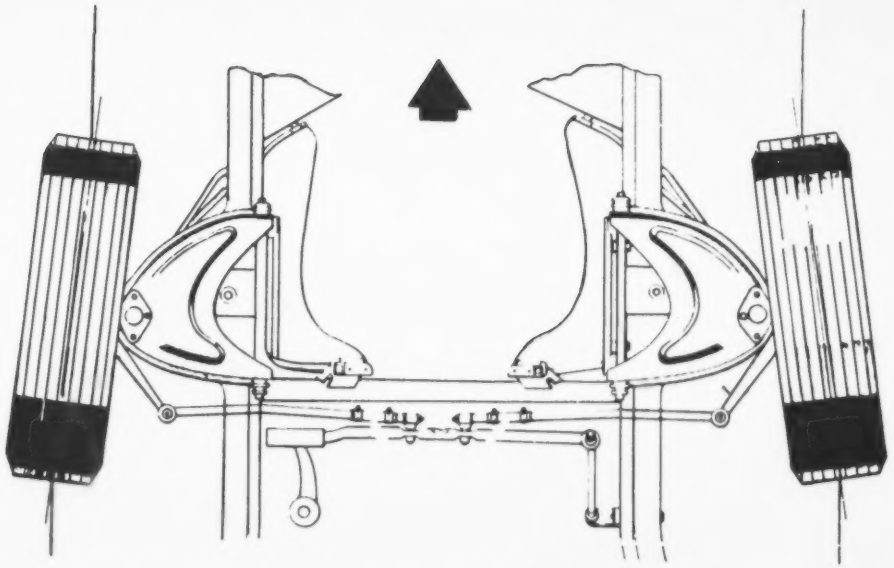


Positive
Caster

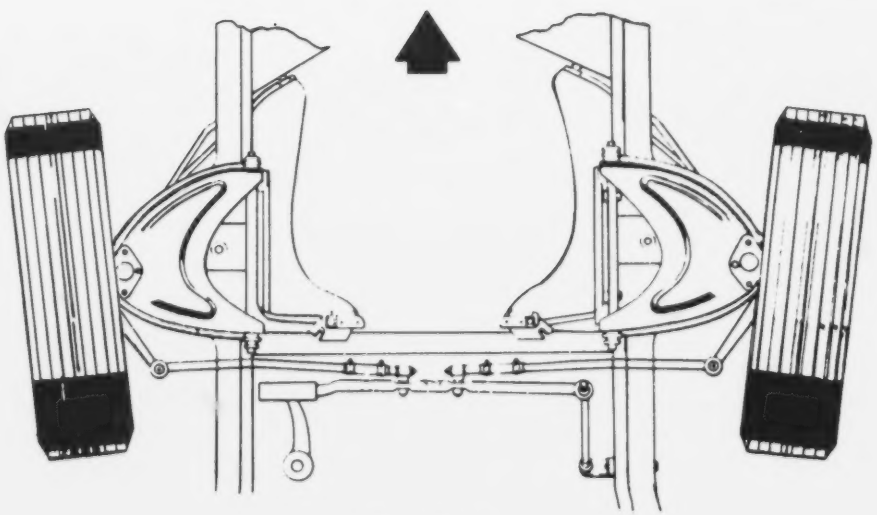


Negative
Caster

Toe-In and Toe-Out

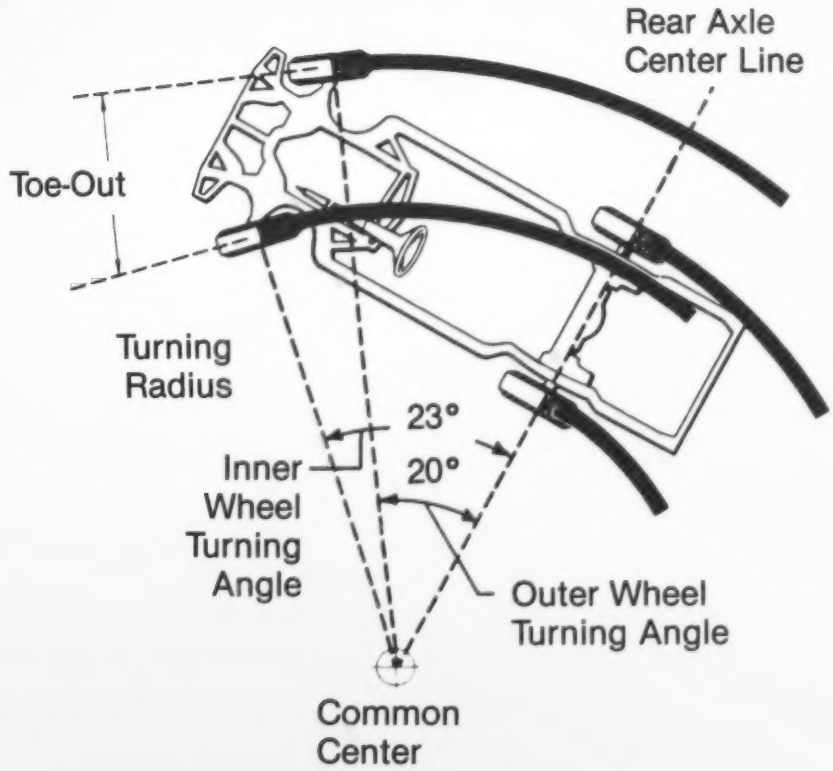


Toe-In

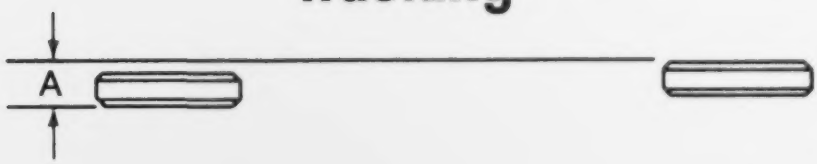


Toe-Out

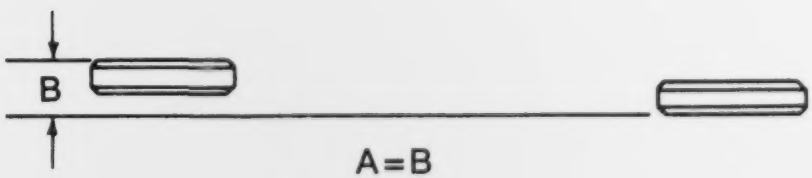
Turning Radius



Tracking

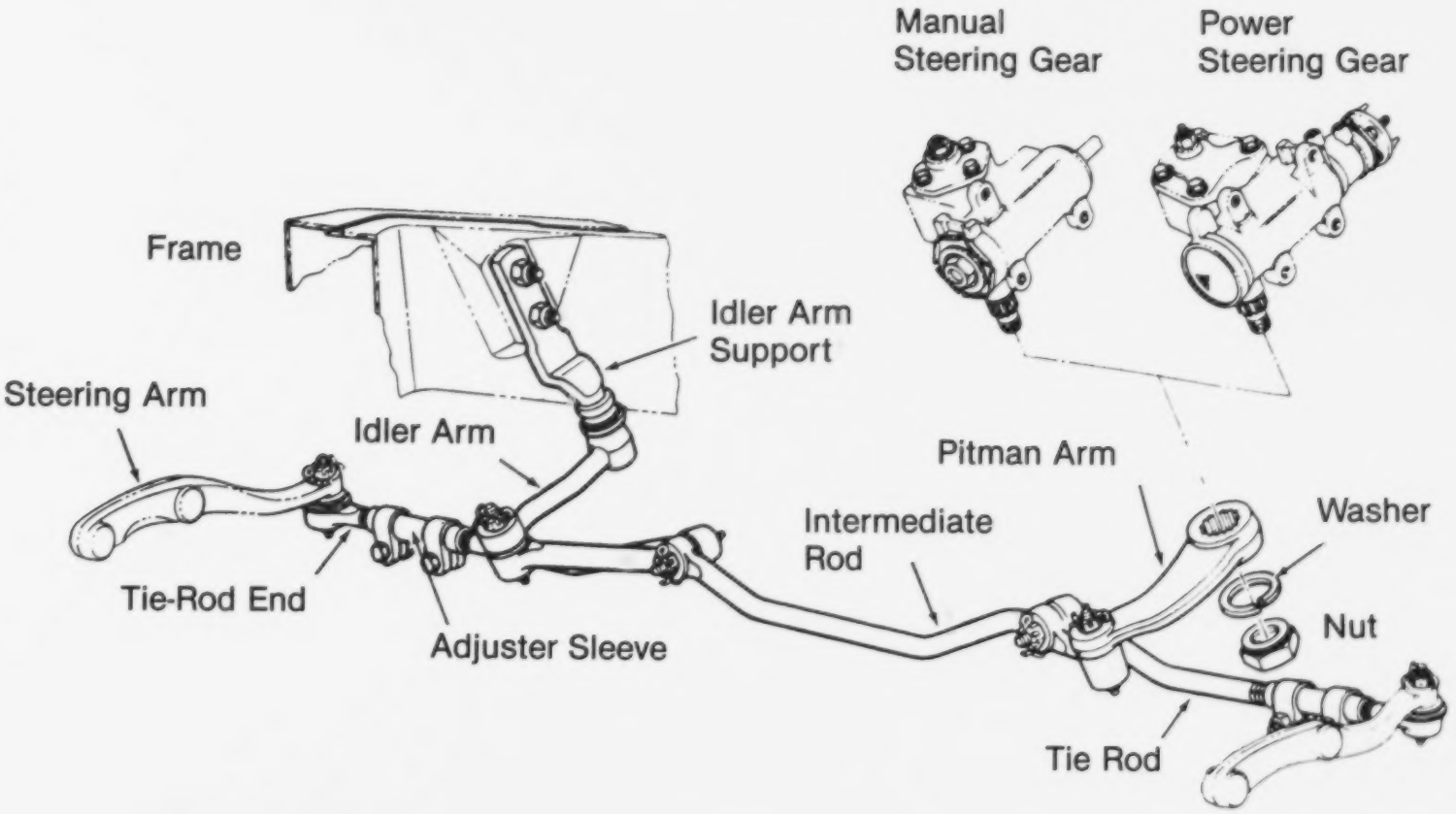


Rear Wheels Front Wheels

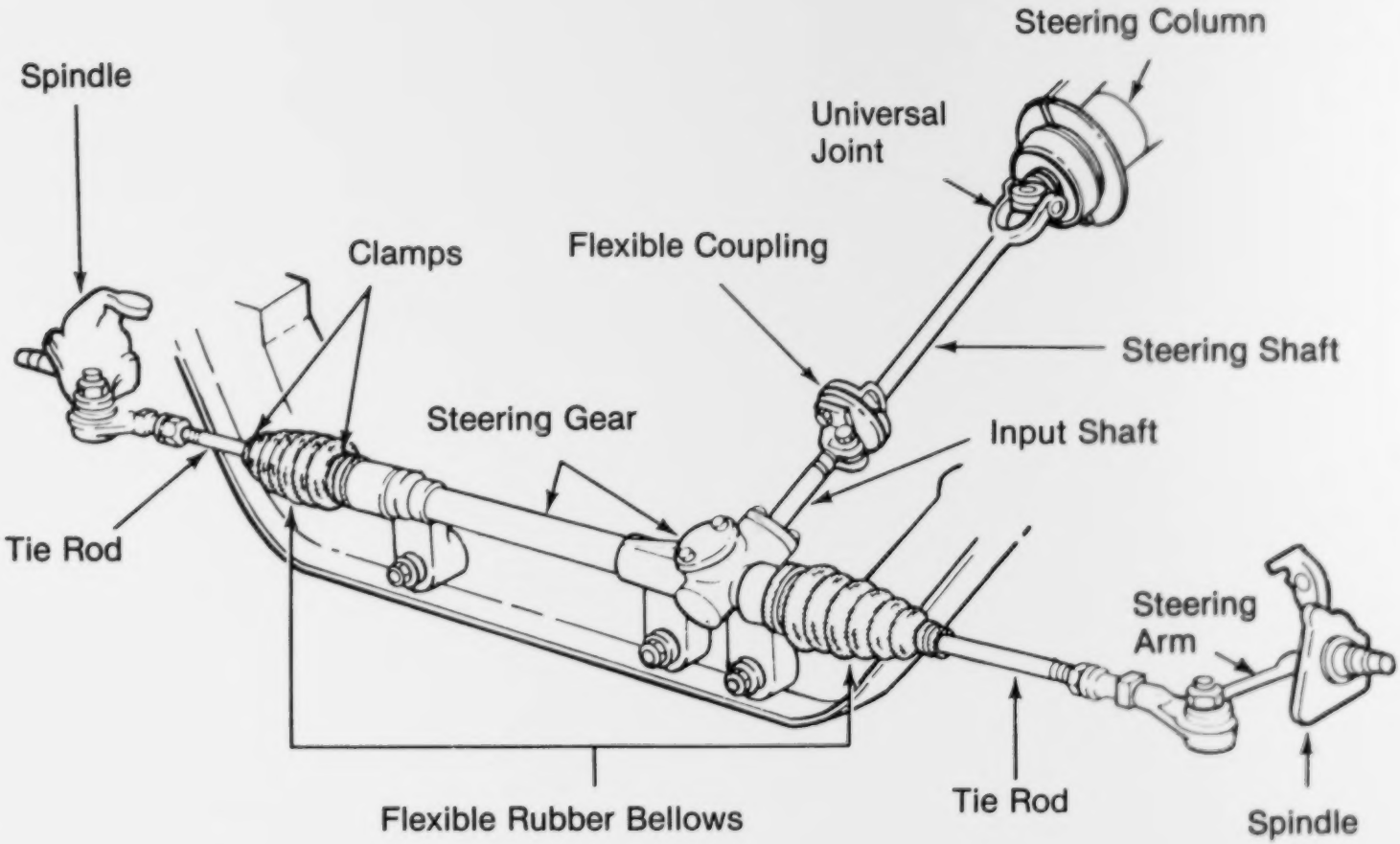


A=B

Pitman Arm Steering



Rack-and-Pinion Steering



ALIGN SUSPENSION AND STEERING COMPONENTS
UNIT III

INFORMATION SHEET

I. Terms and definitions

A. Suspension system — Components on vehicle designed to lessen effects of road surface and vehicle motion

(NOTE: Suspension systems are designed to improve ride, safety, and handling in the vehicle while reducing wear on tires and other components.)

B. Steering system — Components on vehicle designed to allow the driver to control the position of the front wheel assemblies

C. Leaf spring — Suspension system component made of layers of steel strips of varying lengths

D. Strut — Rod designed to provide strength or support

E. Longitudinal — Aligned with the length of an object

F. Transverse — Aligned with the width of an object

G. Tracking — Alignment of front wheels in relation to rear wheels

H. Load distribution — Manner in which weight is arranged on and around support components of a vehicle

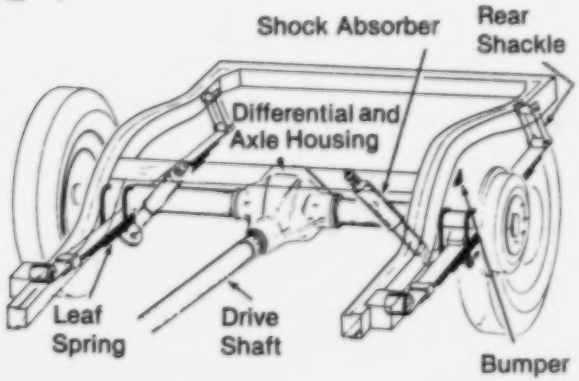
I. Front-end geometry — Relative positioning of front wheel assemblies to each other, to the rear wheels, to the driving surface, and to the vehicle

II. Types of suspension systems (Figures 1-7)

A. Leaf springs

(NOTE: Leaf springs are used primarily for rear suspensions. However, some light trucks have leaf springs used with I-beams for front suspensions.)

FIGURE 1

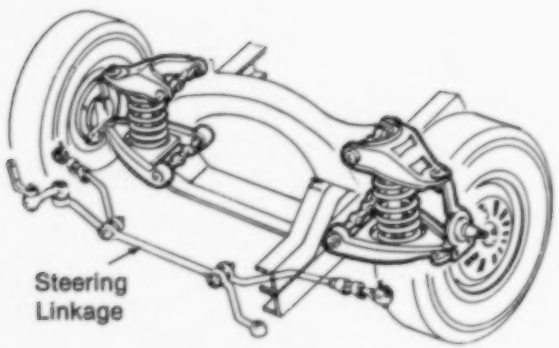


INFORMATION SHEET

B. Coil springs

1. Between lower control arm and a seat in the vehicle frame

FIGURE 2



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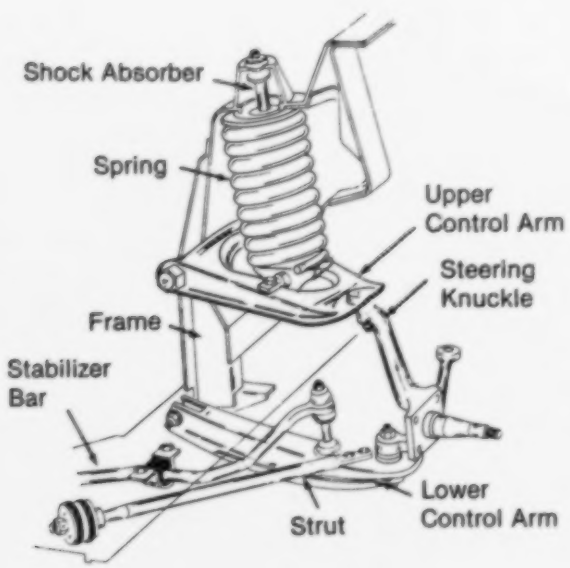
2. Between upper control arm and a seat in the vehicle body

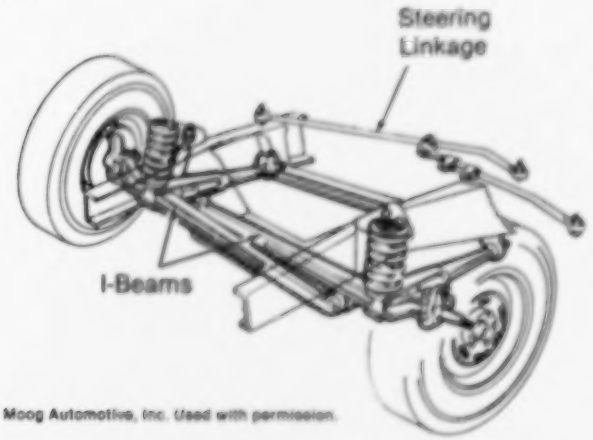
FIGURE 3



INFORMATION SHEET

3. Between an I-beam axle and a seat in the frame

FIGURE 4



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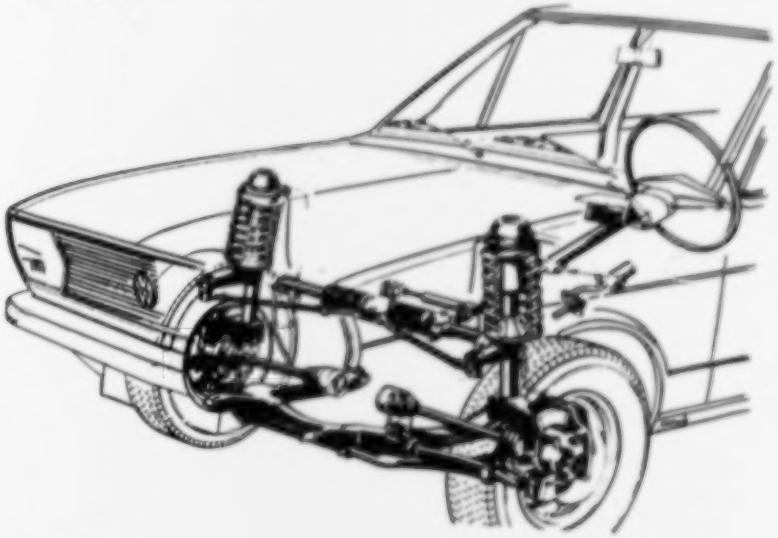
4. Combined with a strut mounted between the lower control arm and a seat in the vehicle body

(NOTE: This design is commonly called a MacPherson strut suspension.)

FIGURE 5



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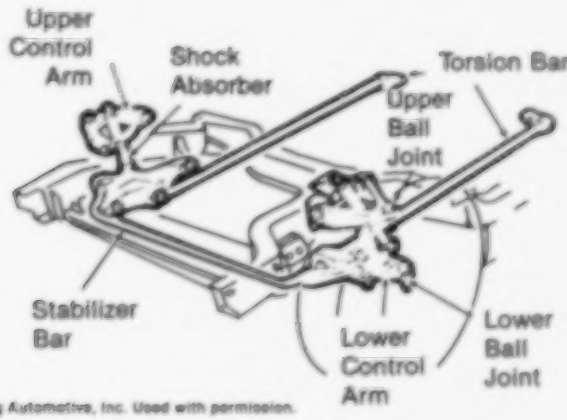
INFORMATION SHEET

C. Torsion bar

1. Connected longitudinally between lower control arm and vehicle frame

FIGURE 6



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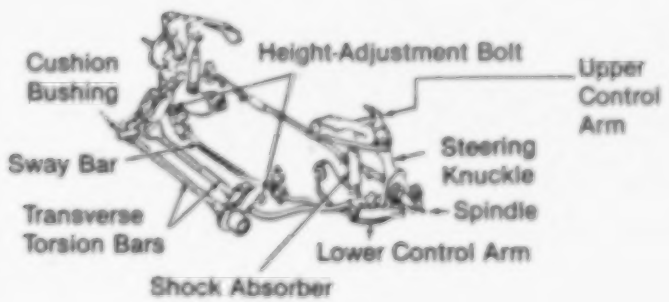
2. Connected transversely between lower control arm and vehicle body

FIGURE 7



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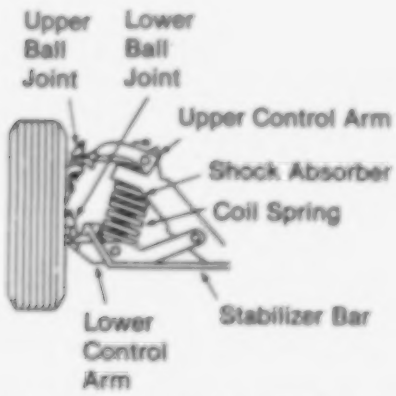
INFORMATION SHEET

III. Parts of a suspension system (Figure 8)

FIGURE 8



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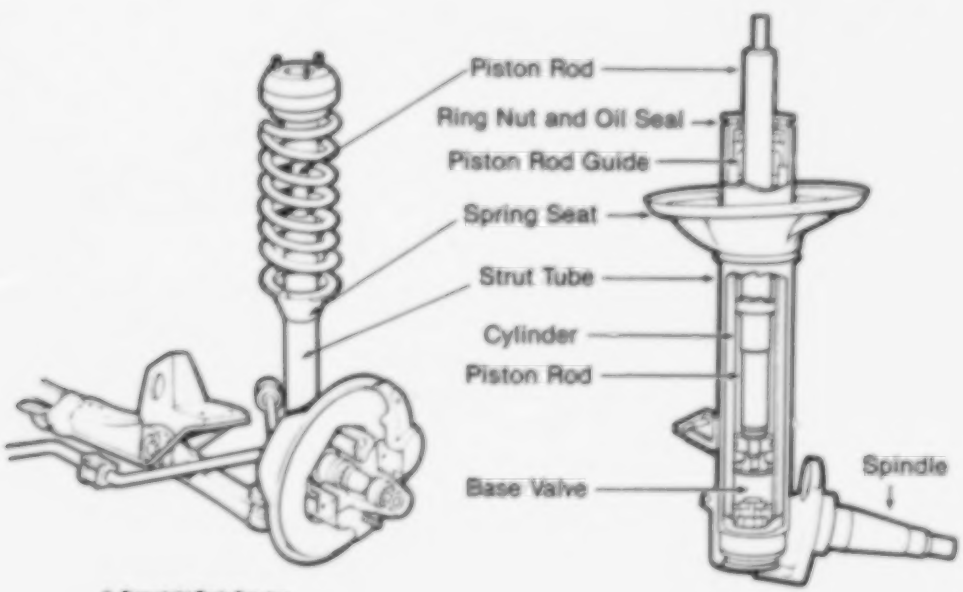
IV. Parts of a MacPherson-type strut assembly (Figure 9)

FIGURE 9



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INFORMATION SHEET

V. Factors that affect suspension alignment

A. Frame and body alignment

B. Tracking

C. Load distribution

D. Alignment of suspension components

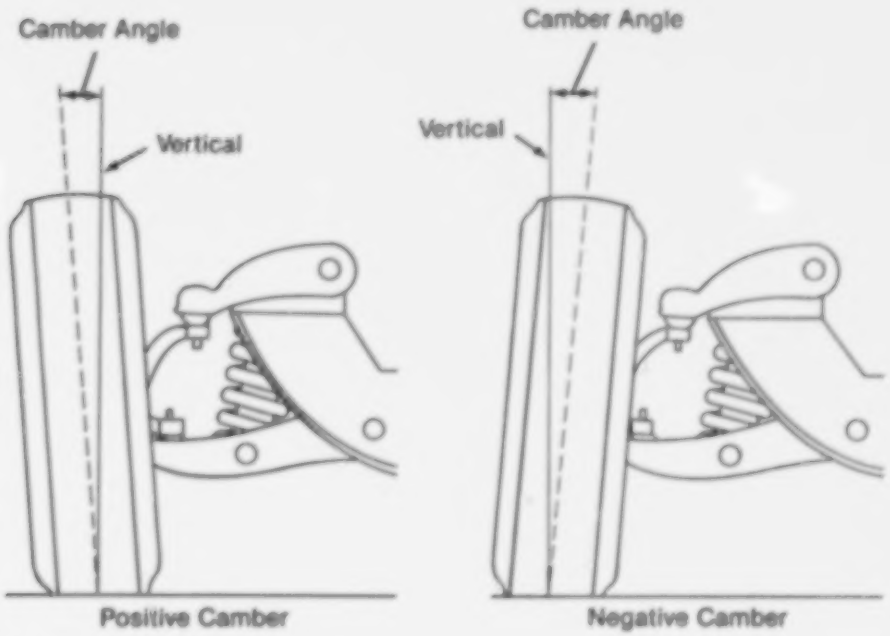
VI. Elements of front-end geometry (Figures 10-17)

(NOTE: The wheels of a vehicle are aligned to each other, to the vehicle, and the driving surface in specific ways to ensure the best handling of the vehicle and least wear of the suspension components. This alignment is called *front-end geometry*.)

A. Camber — Tilt of top of wheel inward or outward when compared to vertical line from center of bottom of wheel

(NOTE: Inward tilt is called *negative camber*, while outward tilt is called *positive camber*.)

FIGURE 10



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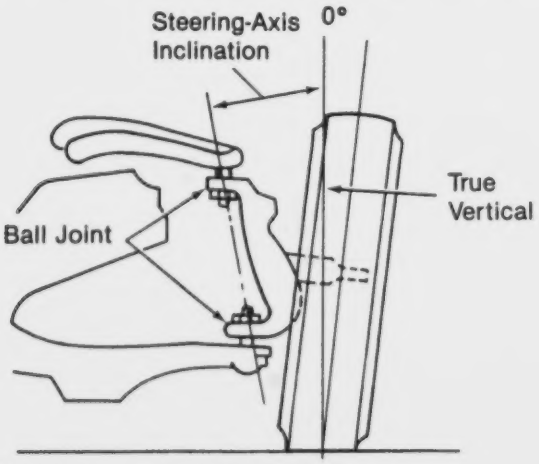
INFORMATION SHEET

B. Steering axis inclination (SAI) — Angle between vertical and a line running through the centers of the upper and lower pivot points of the steering support when viewed from the front

(NOTE: The front wheels of a vehicle pivot left and right to allow the vehicle to turn. The wheel support normally pivots on ball-joints or kingpins and SAI is sometimes called *ball-joint inclination* or *kingpin inclination*.)

FIGURE 11



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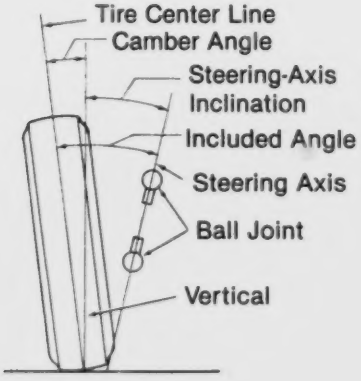
C. Included angle — Total angle from inside of SAI to outside of camber

(NOTE: Since most vehicle have positive camber, the included angle is generally the sum of the SAI and the camber added together.)

FIGURE 12

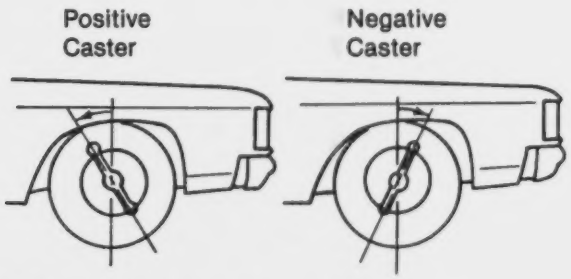


INFORMATION SHEET

D. Caster — Angle between vertical and a line running through the upper and lower pivot points of the steering support when viewed from the side

(NOTE: Caster can be negative or positive. If the upper pivot point is rearward of the lower pivot point, the caster is positive. If the upper pivot point is forward of the lower one, the caster is negative.)

FIGURE 13



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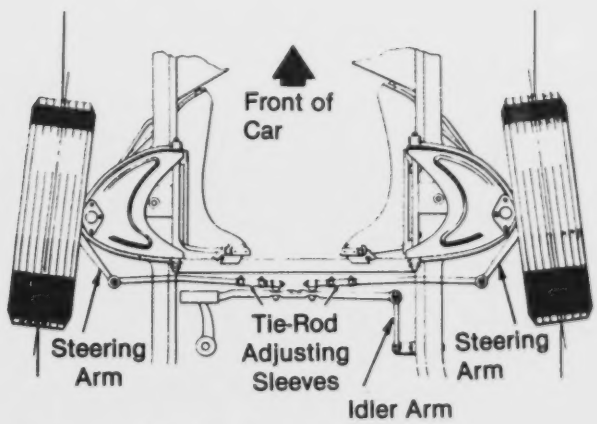
E. Toe — Relationship of front wheels to each other when viewed from above

(NOTE: The two front wheels should be parallel to each other when the vehicle is driving straight. If they are not, the wheels are said to be toed. If the forward parts of the wheel are closer to each other than the rear parts, the vehicle is said to have *toe-in*. If the rear parts of the wheels are closer to each other than the forward parts, the vehicle is said to have *toe-out*. The illustration below shows toe-in. Note, however, that although the illustration shows both wheels pointing in, a vehicle may have a toe condition with only one wheel out of alignment.)

FIGURE 14



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INFORMATION SHEET

F. Turning radius — Difference between the two angles of the front wheels relative to the vehicle when the vehicle is turning

(NOTE: Turning radius refers to the fact that the outer wheel has to make a circle with a longer radius than the inner wheel when a vehicle turns. To make up for this difference, some steering systems are designed to toe-out the outer wheel slightly, as shown in the second figure below.)

FIGURE 15

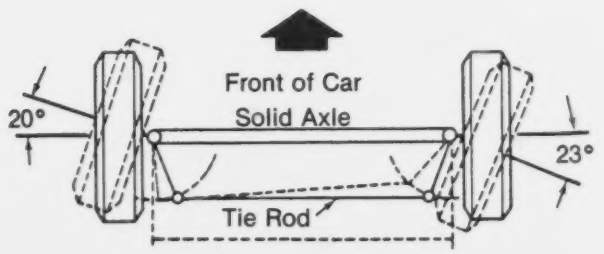

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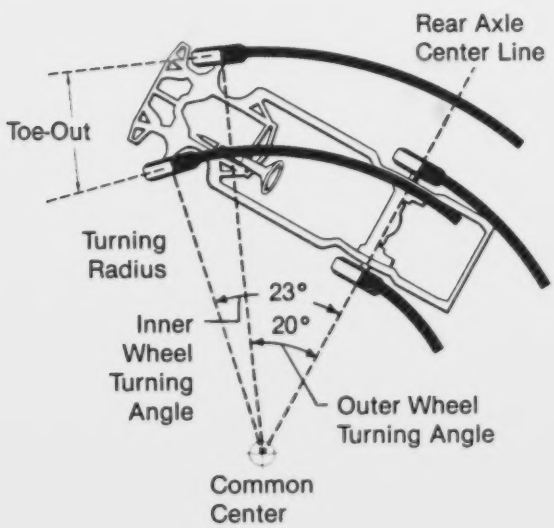
FIGURE 16



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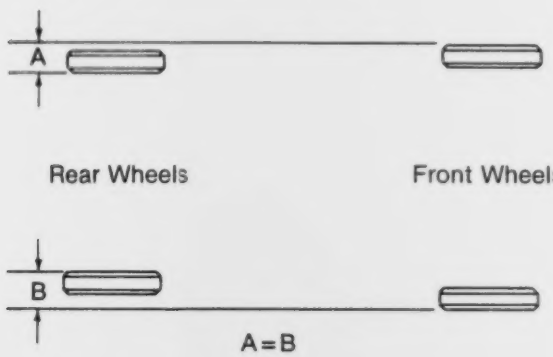
INFORMATION SHEET

G. Tracking — Alignment of the rear wheels to the front wheels

FIGURE 17



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VII. Elements of front-end geometry for correction of suspension misalignment

(NOTE: As with any alignment of vehicle components, the technician's concern is to return suspension and steering components to their designed alignments. Some elements of front-end geometry are designed for relatively easy adjustment, while others can only be aligned by replacing or reshaping of component parts.)

A. Always adjustable — Toe

B. Sometimes adjustable

(NOTE: On most vehicles, camber can be adjusted. However, more and more vehicles are using MacPherson-type struts that do not permit caster adjustment. On some of these designs, camber cannot be adjusted either. Check and follow the manufacturer's procedures.)

1. Camber
2. Caster

C. Not adjustable

1. Steering inclination angle
2. Turning radius
3. Tracking

INFORMATION SHEET

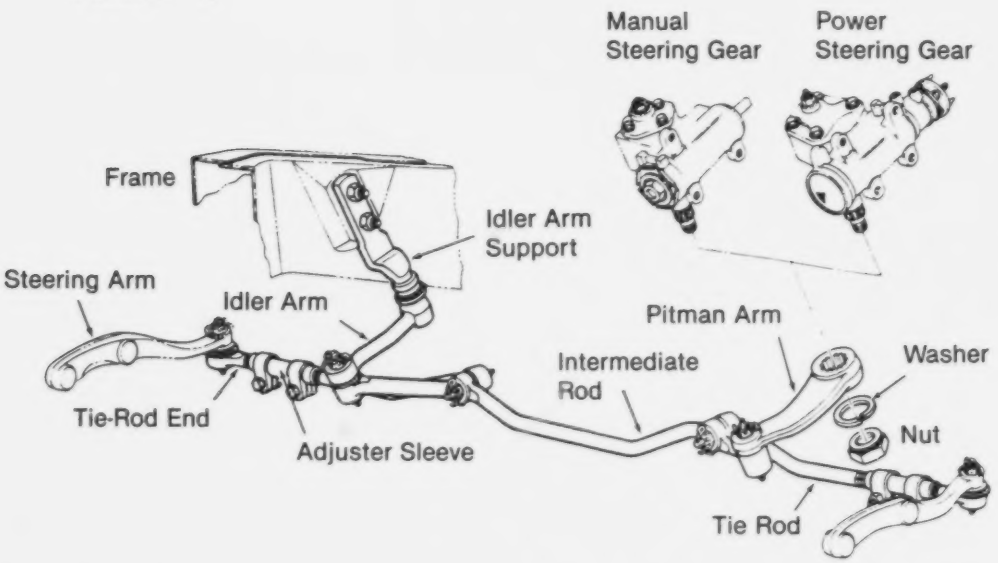
VIII. Types of steering systems (Figures 18 and 19)

(NOTE: Of the two basic types of steering systems—pitman-arm and rack-and-pinion—either can be manual or power-assisted. The auto body technician's main concern is to be able to recognize damaged parts and improper operation. For the most part, the technician will only straighten or replace damaged parts.)

A. Pitman-arm

(NOTE: Basically, in a pitman-arm system, the turning of the steering wheel is transferred to the pitman arm through a gear box. The gears may be of various types such as toothed roller, recirculating ball, gear sector, or stud designs. The action of the gear box swings the pitman arm, which causes the steering rods to shift. This turns the wheel support assembly.)

FIGURE 18



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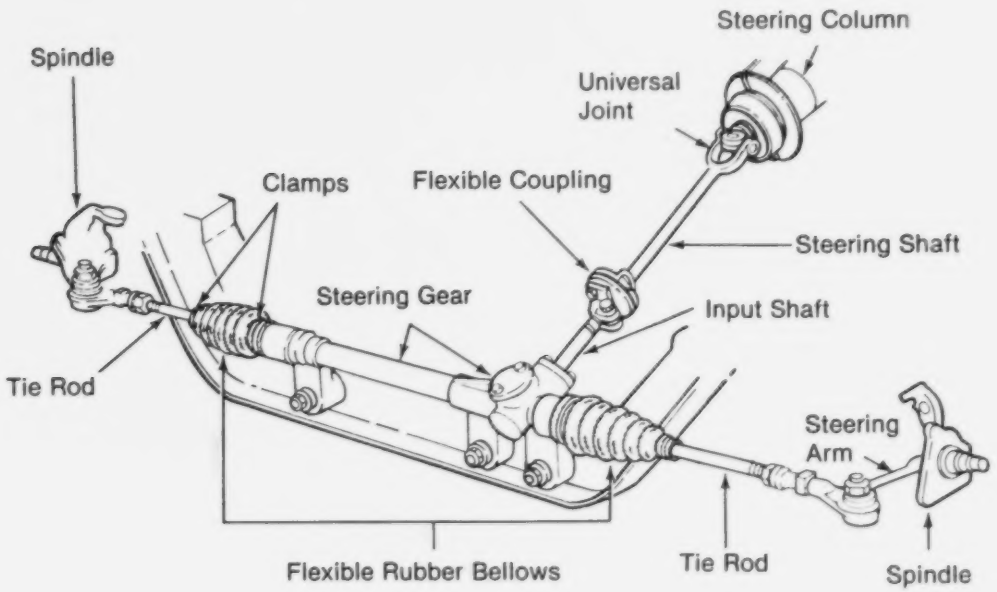
INFORMATION SHEET

B. Rack-and-pinion

(NOTE: Many of today's smaller cars use rack-and-pinion steering system. A small gear or pinion at the end of the steering wheel shaft engages the rack gear. The shifting of the rack moves the tie rods, which rotate the wheel support assemblies in or out.)

FIGURE 19



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ALIGN SUSPENSION AND STEERING COMPONENTS
UNIT III

JOB SHEET #1 — GAUGE A STRUT TOWER

I. Equipment and materials

A. Tram gauges

B. Steel tape

C. Vehicle with damaged strut tower

D. Specifications for vehicle

E. Supports required for vehicle

II. Procedure

(NOTE: This procedure should be done after correcting other types of damage which would interfere with correct strut tower alignment or as part of the repair process.)

A. Visually inspect vehicle to determine damage to strut tower

(NOTE: Collisions often lead to misalignment in one strut tower, allowing the other to be used as a guide and reference. However, the technician must make certain that there is no misalignment in the apparently undamaged strut.)

B. Prepare vehicle for gauging and analysis

(NOTE: See Unit I, Job Sheet #2.)

1. Hang centering gauge at strut location

2. Carefully set datum

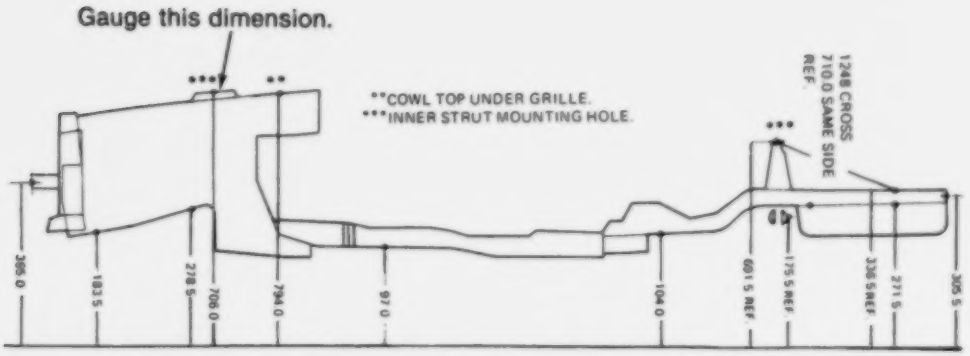
(NOTE: On unitized bodies, hang the gauge from the rocker panel, but set the datum by measuring from the subrail or the point indicated in the specification guide.)

3. If datum is incorrect, complete under body alignment to restore lower strut to correct datum

JOB SHEET #1

C. If given in specification guide, gauge distance from datum line to top of strut tower and compare to specifications (Figure 20)

FIGURE 20



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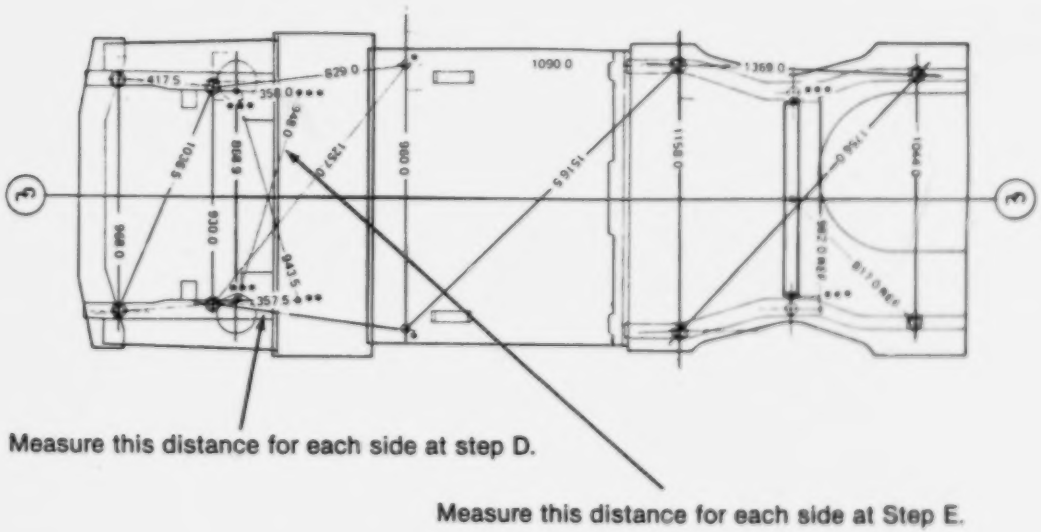
D. Use tram gauge to measure from reference point on strut tower to reference point on cowl on that side (Figure 21)

FIGURE 21



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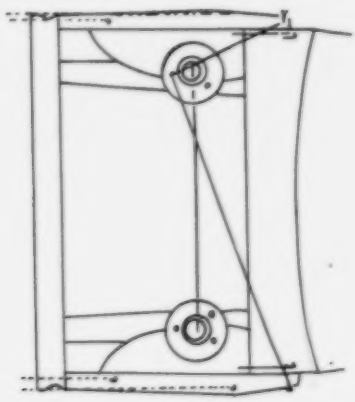
JOB SHEET #1

E. Use tram gauge to measure from reference point on strut tower diagonally to reference point on opposite cowl (See Figure 21.)

F. Compare actual dimensions to specifications

G. Repeat Steps C through F for other strut tower

FIGURE 22



H. Measure the distance between the two strut towers, using the specified reference points, and compare to specifications.

I. If one tower is in correct alignment and the distance between the top of the tower and the datum line cannot be determined, use the other tower to determine alignment

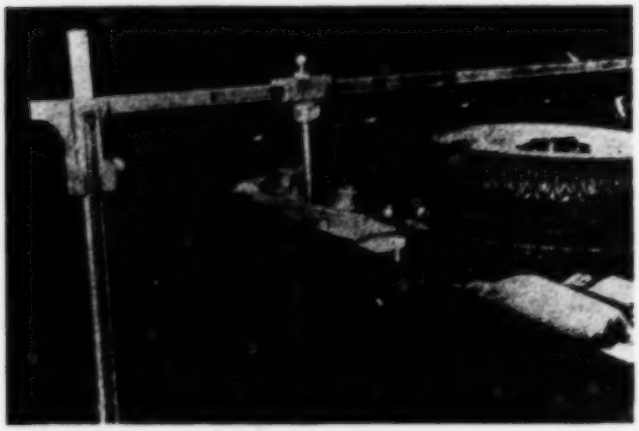
(NOTE: Be sure to check specifications to determine alignment. Some vehicles do not have a true centerline or have offsets in the strut towers.)

1. Set a tram gauge (or strut tower gauge) to indicate the tops of the towers

2. Attach it to sight gauge stands

3. Check height of towers to cowl (Figure 23)

FIGURE 23



J. Analyze tower alignment in relation to desired position and plan repair procedure

K. Continue with repair procedure, or clean work area, put away equipment and materials, and store vehicle as required

ALIGN SUSPENSION AND STEERING COMPONENTS
UNIT III

JOB SHEET #2 — REMOVE AND REPLACE A MACPHERSON-TYPE STRUT

I. Introduction

A. Carefully study the manufacturer's manual to make sure that you understand how the strut is assembled and how the assembly is fastened to the vehicle

B. When removing the strut assembly, be sure to remove the mounting fasteners and not the top strut assembly fastener; the assembly fasteners should be removed only after the assembly is off the vehicle

C. Use a suitable spring compression tool whenever required during removal, disassembly, reassembly, and installation

> **CAUTION**
>
> Suspension springs are under a great deal of pressure and cause personal injury or extensive damage if pressure is not controlled properly.

D. If the strut is to be placed in a vise for disassembly, use padding; do not clamp on the strut directly

E. Note which elements of front-end geometry are adjustable for that particular vehicle

(NOTE: On many vehicles with MacPherson-type struts, the camber and caster are set at the factory and are not adjustable, while on other models camber is adjustable. Often manufacturer's instructions give guidance on marking component locations to ensure that factory standards are retained.)

F. If damage is such that front-end geometry has been disturbed and cannot be restored following manufacturer's guidelines, obtain a universal strut alignment kit and follow the instructions provided

G. Do not reinstall strut assembly or attempt to adjust front-end geometry until the upper and lower mounting fixtures on the vehicle have been restored to proper alignment

H. If in doubt about whether a damaged part of the strut assembly is repairable, replace it

II. Procedure — Refer to the manufacturer's service manual for the make and model of vehicle as equipped

ALIGN SUSPENSION AND STEERING COMPONENTS
UNIT III

JOB SHEET #3 — ALIGN SUSPENSION AND STEERING COMPONENTS

I. Introduction

A. Carefully study the manufacturer's service manual so that you understand which components can be adjusted

B. Make adjustments as necessary during the repair process to allow correct gauging and alignment

C. Be sure that suspension and steering components are not damaged or distorted if they are to be used as references or if they affect other alignments

D. Replace components that have been badly damaged

II. Procedure — Refer to manufacturer's service manual for the make and model of vehicle as equipped

ALIGN SUSPENSION AND STEERING COMPONENTS
UNIT III

TEST

NAME _____ SCORE _____

1. Match to their correct definitions terms associated with aligning suspension and steering components. Write the number of the term in the space beside its correct definition.

_____a. Components on vehicle designed to lessen effects of road surface and vehicle motion

_____b. Components on vehicle designed to allow the driver to control the position of the front wheel assemblies

_____c. Suspension system component made of layers of steel strips of varying lengths

_____d. Rod designed to provide strength or support

_____e. Aligned with the length of an object

_____f. Aligned with the width of an object

_____g. Alignment of front wheels in relation to rear wheels

_____h. Manner in which weight is arranged on and around support components of a vehicle

_____i. Relative positioning of front wheel assemblies to each other, to the rear wheels, to the driving surface, and to the vehicle

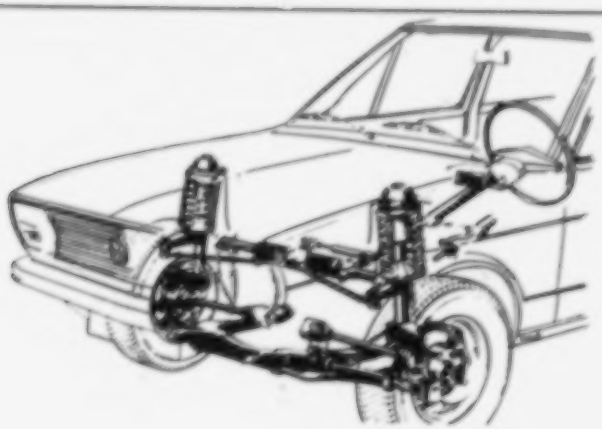
1. Tracking
2. Strut
3. Steering system
4. Front-end geometry
5. Leaf spring
6. Transverse
7. Load distribution
8. Longitudinal
9. Suspension system

2. Identify types of suspension systems. Write the correct name in the space provided with each illustration.

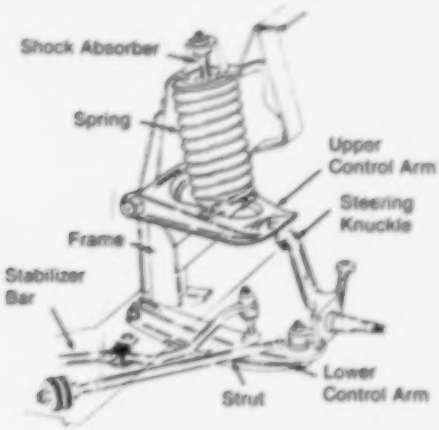
Leaf spring
Coil spring between lower control arm and a seat in the vehicle frame
Coil spring between upper control arm and a seat in the vehicle body
Coil spring between an I-beam axle and a seat in the frame
Coil spring combined with a strut
Torsion bar connected longitudinally
Torsion bar connected transversely

TEST

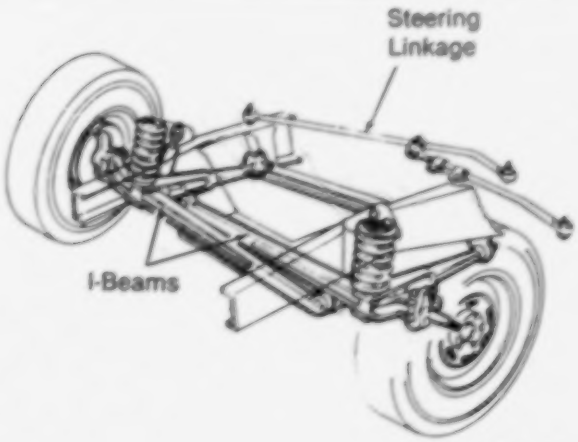
a. _____



b. _____

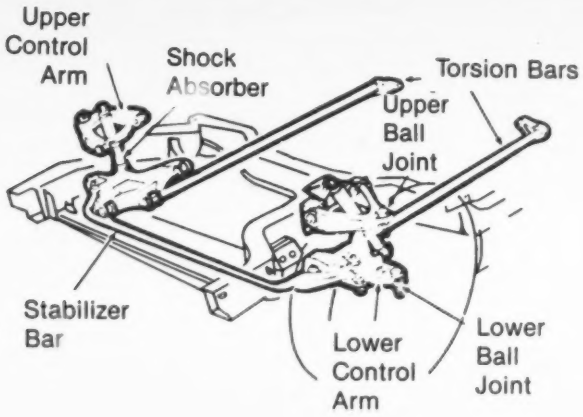

Shock Absorber
Spring
Upper Control Arm
Steering Knuckle
Frame
Stabilizer Bar
Lower Control Arm
Strut

c. _____

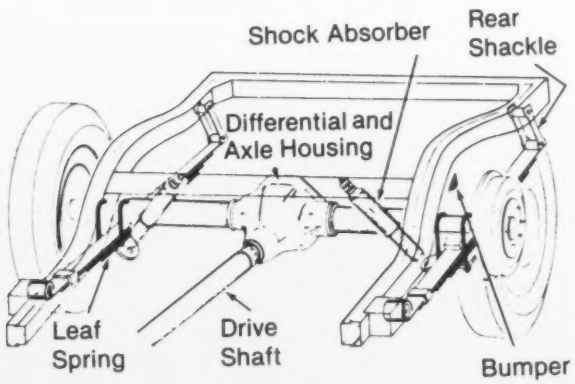

Steering Linkage
I-Beams

TEST

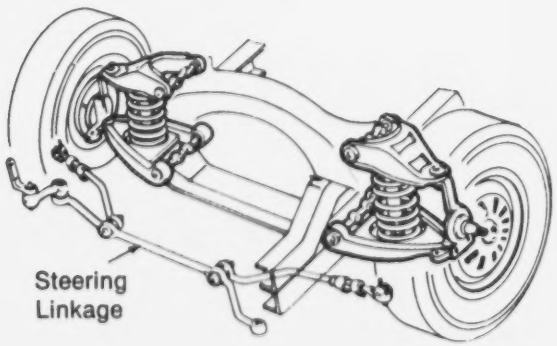
d. _____


Upper
Control
Arm
Shock
Absorber
Torsion Bars
Upper
Ball
Joint
Stabilizer
Bar
Lower
Control
Arm
Lower
Ball
Joint

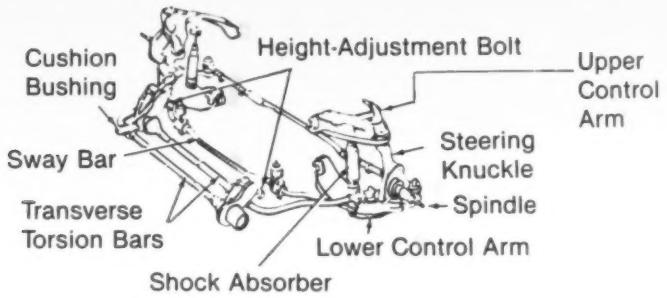
e. _____


Shock Absorber
Rear
Shackle
Differential and
Axle Housing
Leaf
Spring
Drive
Shaft
Bumper

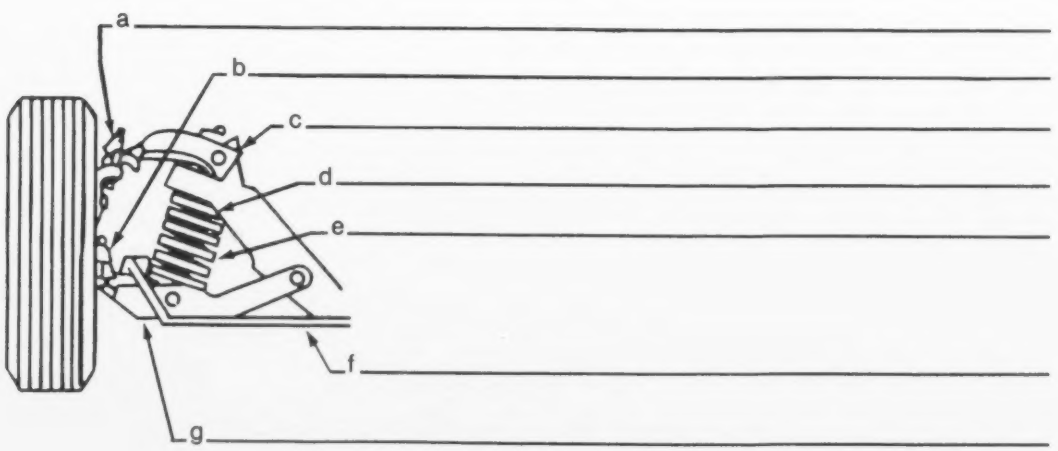
f. _____


Steering
Linkage

g. _____

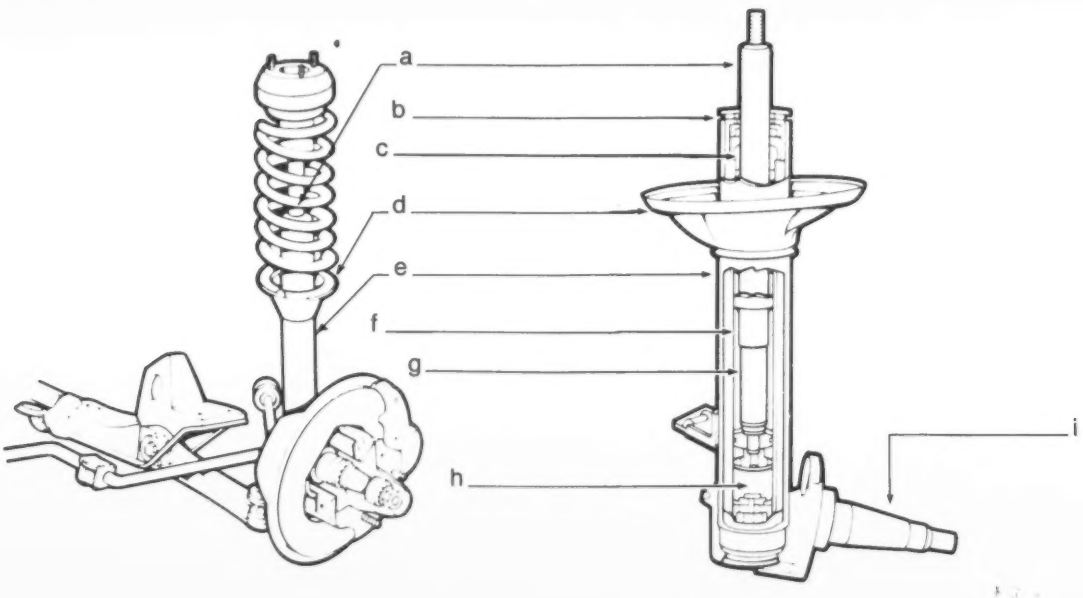


3. Label the parts of a suspension system in the drawing below. Write the correct names in the spaces provided.



TEST

4. Label the parts of a MacPherson-type strut system. Write the correct names in the spaces provided.



5. List factors that affect suspension alignment in the spaces below.

a. _____

b. _____

c. _____

d. _____

6. Match elements of front-end geometry to their correct descriptions. Write the number of each element beside its correct description.

_____a. Tilt of top of wheel inward or outward when compared to vertical line from center of bottom of wheel

_____b. Angle between vertical and a line running through the centers of the upper and lower pivot points of the steering support when viewed from the front

_____c. Total angle from inside of SAI to outside of camber

1. Caster
2. Camber
3. Steering angle inclination
4. Toe

TEST

_____d. Angle between vertical and a line running through the upper and lower pivot points of the steering support when viewed from the side — 5. Tracking

_____e. Relationship of front wheels to each other when viewed from above — 6. Turning radius

_____f. Difference between the two angles of the front wheels relative to the vehicle when the vehicle is turning — 7. Included angle

_____g. Alignment of the rear wheels to the front wheels

7. Distinguish among elements of front-end geometry by whether they are adjustable. Write an "A" beside those that are always adjustable, an "S" beside those that are sometimes adjustable, and an "N" beside those that are not adjustable.

_____a. Camber

_____b. Caster

_____c. Steering inclination angle

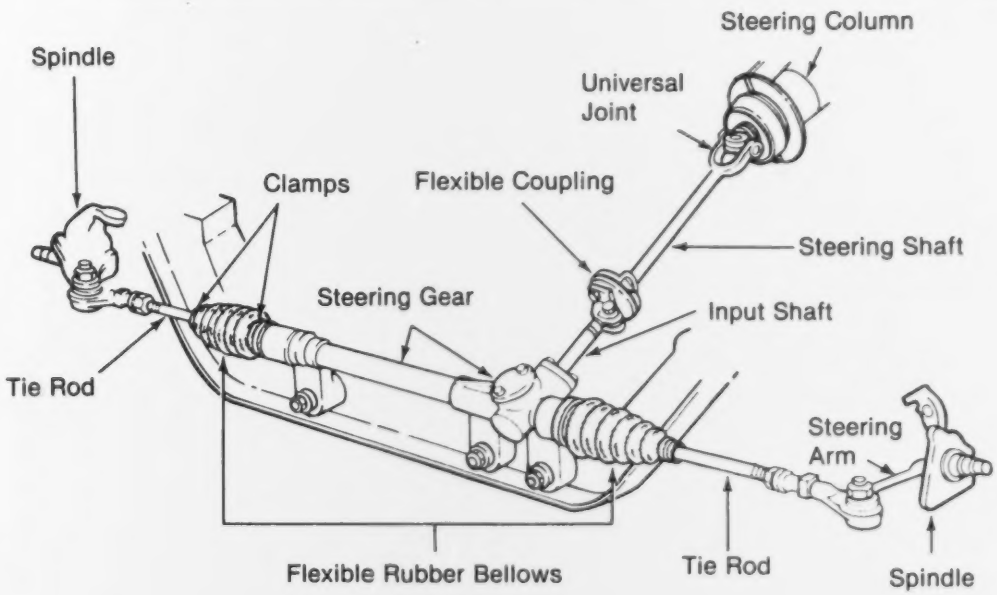
_____d. Toe

_____e. Turning radius

_____f. Tracking

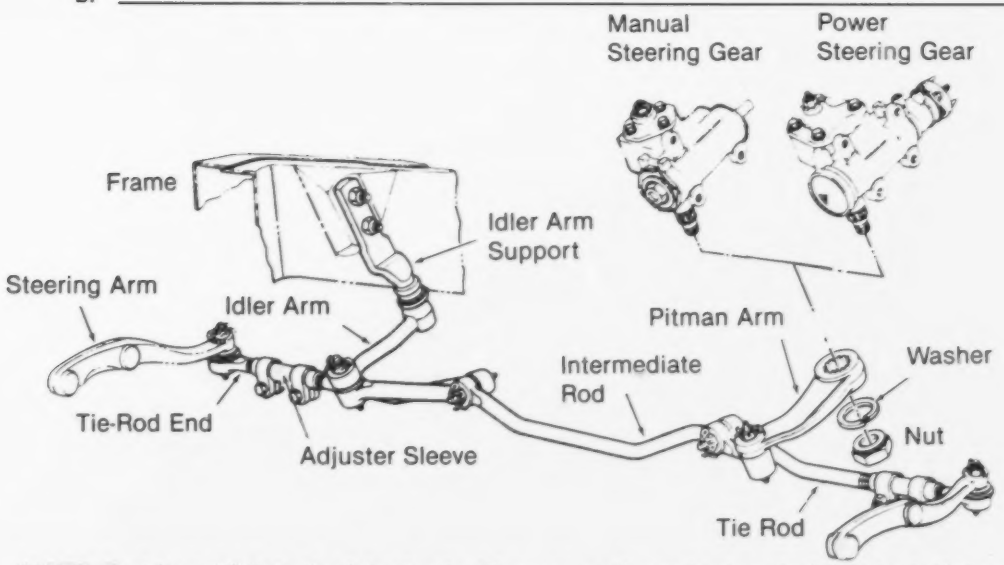
8. Label types of steering systems. Write the names in the spaces provided.

a. _____



TEST

b. _____



(NOTE: Test item #9 lists the job sheets. They are an important part of this test. If they have not been completed, check with your instructor.)

9. Demonstrate the ability to

   a. Gauge a strut tower.

   b. Remove and replace a MacPherson-type strut.

   c. Align suspension and steering components.

ALIGN SUSPENSION AND STEERING COMPONENTS
UNIT III

ANSWERS TO TEST

1. a. 9 d. 2 g. 1
   b. 3 e. 8 h. 7
   c. 5 f. 6 i. 4

2. a. Coil spring combined with a strut
   b. Coil spring between upper control arm and a seat in the vehicle body
   c. Torsion bar connected longitudinally
   d. Coil spring between an I-beam axle and a seat in the frame
   e. Leaf spring
   f. Coil spring between lower control arm and a seat in the vehicle frame
   g. Torsion bar connected transversely

3. a. Upper ball joint
   b. Lower ball joint
   c. Upper control arm
   d. Shock absorber
   e. Coil spring
   f. Stabilizer bar
   g. Lower control arm

4. a. Piston rod
   b. Ring nut and oil seal
   c. Piston rod guide
   d. Spring seat
   e. Strut tube
   f. Cylinder
   g. Piston rod
   h. Base valve
   i. Spindle

5. (In any order)

   a. Frame and body alignment
   b. Tracking
   c. Load distribution
   d. Alignment of suspension components

6. a. 2 d. 1 g. 5
   b. 3 e. 4
   c. 7 f. 6

ANSWERS TO TEST

7. a. S
   b. S
   c. N
   d. A
   e. N
   f. N

8. a. Rack-and-pinion
   b. Pitman arm

9. Performance skills evaluated to the satisfaction of the instructor.

REPLACE STRUCTURAL PANELS
UNIT IV

UNIT OBJECTIVE

After completing this unit, the student should be able to determine and perform correct repair procedures for damaged structural panels. The student will show this ability by completing job sheets and unit test with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match to their correct definitions terms associated with replacing structural panels.
2. Match choices for correction of structural panel damage to their correct applications.
3. Identify types of structural panel welds.
4. Select from a list methods of welded panel removal.
5. Demonstrate the ability to
   a. Section a quarter panel.
   b. Replace a door skin.
   c. Replace an outer rocker panel.

REPLACE STRUCTURAL PANELS
UNIT IV

INFORMATION SHEET

I. Terms and definitions

A. Short cut — To replace only the damaged portion of a body panel

B. Sectioning — The cutting and welding in of a panel to fit the damaged area

C. Body clip — Replacing part of the body as a unit

(NOTE: The replacement part is purchased intact, often removed from another vehicle. Unibody designs use panels and welds for structural strength. The repair technician must make certain that the use of body clips conforms to design requirements.)

EXAMPLES: Quarter panels, floor, top

D. R and R — Remove and replace

E. R and I — Remove and reinstall

F. Repanel — Replacing the outer panel (skin) of a door using the original inner door panel

G. Flanging — Crimping the panel on a door with a hammer and dolly block or crimping tool

II. Choices for correction of structural panel damage

(NOTE: The correct choice for repairing damage is largely a matter of the time and money required to do a satisfactory job. The primary concerns in panel repair and replacement are appearance and tightness. The technician must weigh the cost of each possible method in these terms.)

A. Reshape part with force and/or heat in place — Used for minor damage or as a rough adjustment of major damage

CAUTION

Do not apply heat to gas-filled energy-absorbing bumpers. Do not heat HSS or HSLA metals beyond manufacturer's recommendations.

B. Replace entire part — Used whenever replacement parts are available and the cost in time and money is less than the other methods

C. Use filler to restore shape — Used for minor damage or to finish correction procedure for some other methods

INFORMATION SHEET

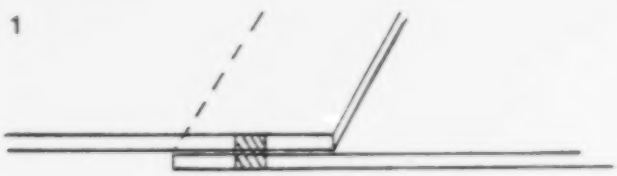
D. Cut away portion of damaged part and replace with portion of another part — Used to repair damage that cannot be easily reshaped on parts that are difficult to remove or to find replacements for

III. Types of structural panel welds (Figures 1-8)

A. Lap joints

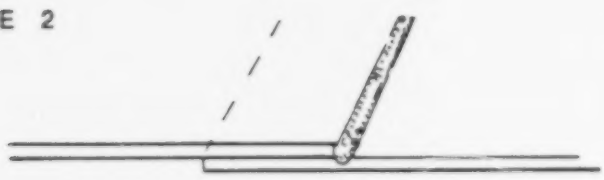
1. Spot welded

FIGURE 1



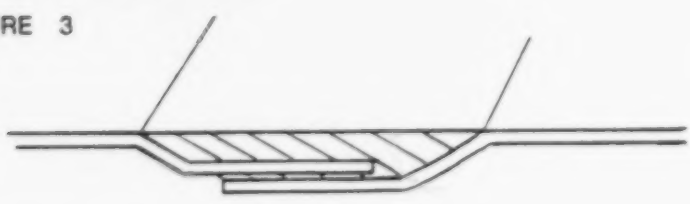
2. Fillet welded

FIGURE 2



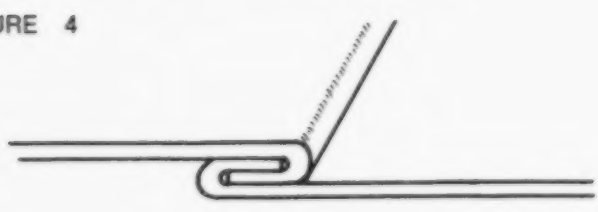
3. Welded and filled

FIGURE 3



4. Crimped and welded

FIGURE 4



REPLACE STRUCTURAL PANELS
UNIT IV

SUGGESTED ACTIVITIES

I. Unit contents

A. Objective sheet

B. Suggested activities

C. Transparency masters

1. TM #1 — Types of Structural Panel Welds

2. TM #2 — Types of Structural Panel Welds (Continued)

D. Information sheet

E. Job sheets

1. Job Sheet #1 — Section a Quarter Panel

2. Job Sheet #2 — Replace a Door Skin

3. Job Sheet #3 — Replace an Outer Rocker Panel

F. Unit test

G. Answers to test

II. Instructor's guide

A. Review unit and plan presentation.

B. Obtain materials necessary to supplement presentation.

1. Media

(NOTE: The programs listed below are available from Teaching Aids Incorporated, Post Office Box 1798, Costa Mesa, California 92628-0798.)

a. *Door Panel Replacement*

b. *Quarter Panel Replacement*, Parts 1 and 2

2. Transparencies and competency profiles

(NOTE: Transparencies and competency profiles for this manual are available from the State Department of Vocational and Technical Education, Curriculum and Instructional Materials Center, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074.)

SUGGESTED ACTIVITIES

C. Provide students with unit.

D. Introduce unit.

SUGGESTIONS:

- Discuss the costs involved in doing various types of repairs compared to those of replacing panels.
- Use detail drawings or actual vehicles to show how structural panels are used to strengthen unibody designs.
- Provide the students with articles from trade journals or newspapers that describe failures of repairs.

E. Discuss unit and specific objectives, relating objectives to previous units and explaining how mastery of the specific objectives will lead to mastery of the unit objectives.

F. Discuss information sheet.

1. Use Information Sheet, Section I to discuss terms associated with structural panel replacement.

   SUGGESTIONS:

   - Show students examples of terms when possible.
   - Show students work orders using terms and abbreviations and relate terms to the job sheets.

2. Use Information Sheet, Section II to discuss choices for correction of structural panel damage, emphasizing tightness and appearance as well as cost considerations.

   SUGGESTIONS:

   - Demonstrate each technique, explaining factors to consider in choosing each.
   - Relate each technique to the job sheets and to previously studied job sheets.

3. Use Information Sheet, Section III and transparencies to discuss types of structural panel weld joints.

   SUGGESTIONS:

   - Discuss applications of the various types of welds.
   - Invite an automotive engineer or other resource person to talk to the class about the use of various welds and the importance of restoring factory welds, especially in unibody designs.

SUGGESTED ACTIVITIES

4. Use Information Sheet, Section IV to discuss methods of removing welded panels.

   SUGGESTIONS:

   - Demonstrate each method, relating them to the types of welds and types of panels and explaining why they are or are not suited for various applications.
   - Review the use of the various tools and related safety rules and guidelines.
   - Allow students to practice techniques with various metals and designs.
   - Demonstrate job sheet procedures and allow student practice.

E. Review unit.

F. Give test.

G. Critique test and discuss in class.

H. Reteach and retest as necessary.

I. Complete appropriate sections of competency profile.

III. Unit references

A. Coghlan, David A. *Automotive Chassis Systems: Steering, Suspension, Alignment, and Brakes*. 2nd ed. Boston: Breton Publishers, a division of Wadsworth, Inc., 1985.

B. Crouse, William H., and Donald L. Anglin. *Automotive Body Repair and Refinishing*. 2nd ed. New York: McGraw-Hill Book Company/Gregg Division, 1986.

C. *Gauging and Analyzing Collision Damage*. Grand Island, Nebraska: Chief Automotive Systems, 1978.

D. Manual, Edward F., and Wayman R. Penner. *Auto Body Repair and Repainting*. Stillwater, Oklahoma: State Department of Vocational and Technical Education/ Curriculum and Instructional Materials Center, 1974.

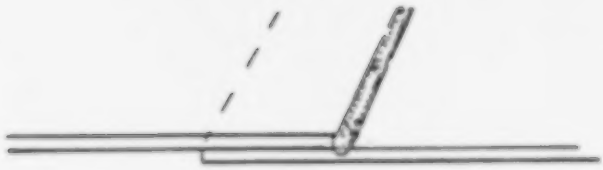
E. *The New Science of Unibody Repair*. Milwaukee, Wisconsin: Blackhawk Applied Power, Inc., Automotive Division, 1982.

F. Rhone, L.C., and H. David Yates. *Total Auto Body Repair*. 2nd ed. Indianapolis: Bobbs-Merrill Educational Publishing, 1983.

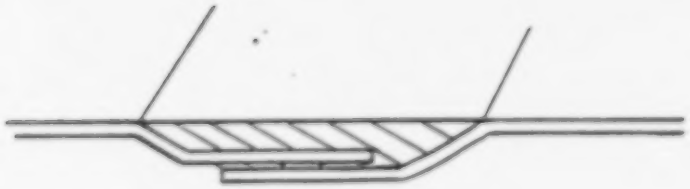
Types of Structural Welds

Lap Joints

Spot Welded



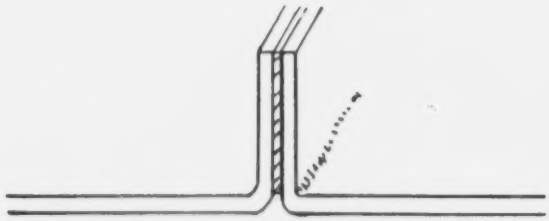
Fillet Welded



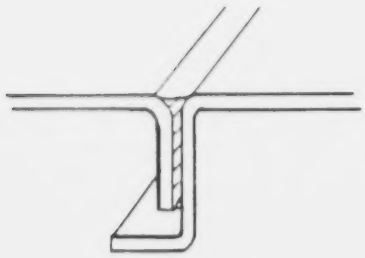
Welded and Filled

Crimped and Welded

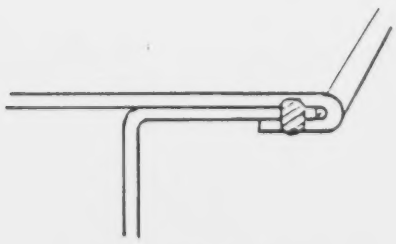
Types of Structural Welds
(Continued)



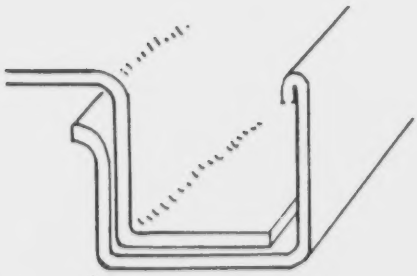
Pinch Weld Joint



Couch Joint



Hemming Joint

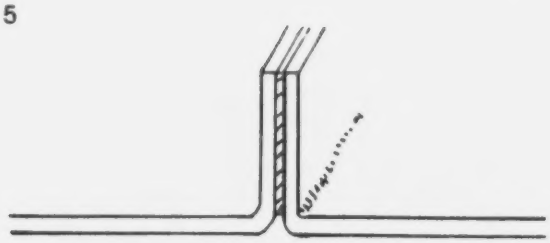


Gutter Joint

INFORMATION SHEET

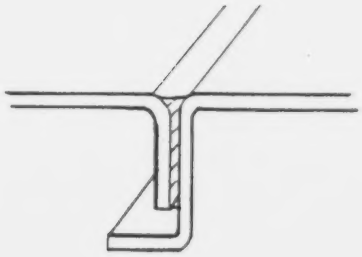
B. Pinch weld joint

FIGURE 5



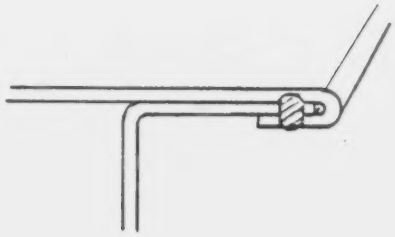
C. Couch joint

FIGURE 6



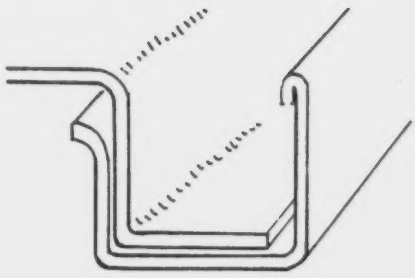
D. Hemming joint

FIGURE 7



E. Gutter joint

FIGURE 8



INFORMATION SHEET

IV. Methods of removing welded panels

A. Panel cutter

B. Cutting torch

(NOTE: Stay at least two inches outside the panel surface area so that the edges will not be distorted by the heat.)

C. Plasma arc

D. Drilling spot welds

E. Hacksaw

F. Hammer and chisel

REPLACE STRUCTURAL PANELS
UNIT IV

JOB SHEET #1 — SECTION A QUARTER PANEL

I. Tools and equipment

A. Masking tape

B. Cutting equipment appropriate for type of metal involved

C. Replacement panel

D. Welding equipment appropriate for type of metal involved and installation procedure

E. Sander and discs for paint removal and surface preparation

F. Clamps

G. Body filler

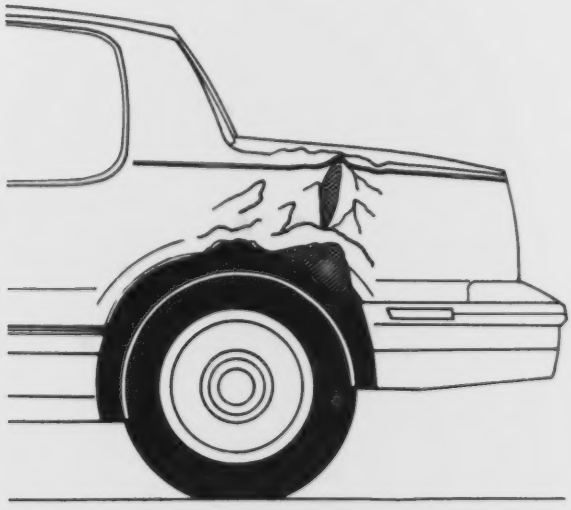
II. Procedure

A. Return damaged panel to correct alignment as much as possible

(NOTE: Correcting alignment will help to make a more accurate repair and will allow the technician to better determine the type of repair that is required.)

B. Determine area to be replaced (Figure 9)

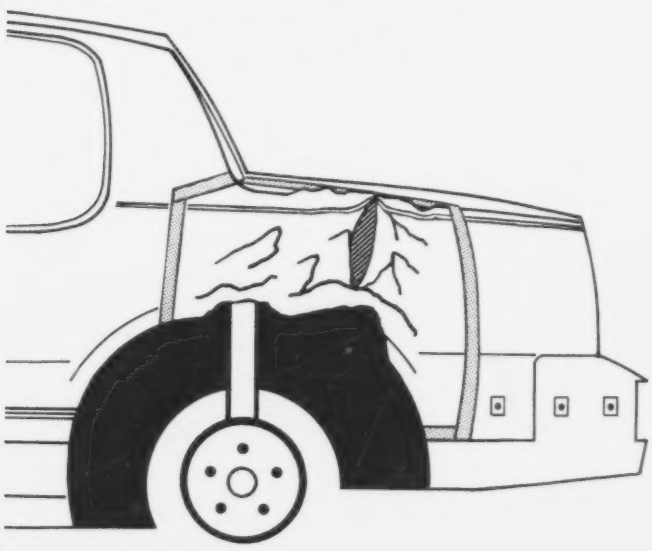
FIGURE 9



C. Apply masking tape along cut lines (Figure 10)

(NOTE: The tape should be placed outside the damaged area so that as much damage as possible will be repaired by the replacement section. Keep cut lines straight or along natural contours of the vehicle. For unibody construction, be careful not to weaken structural strengthening features.)

FIGURE 10



D. Obtain replacement panel

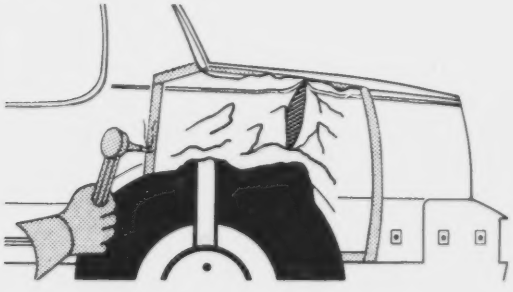
(NOTE: Replacement panels or partial panels may be obtained from vehicle manufacturers or salvage yards.)

E. Remove damaged panel using an oxyacetylene torch or plasma arc cutter (Figure 11)

CAUTION

Do not use oxyacetylene equipment on HSS or HSLA metals.

FIGURE 11



JOB SHEET #1

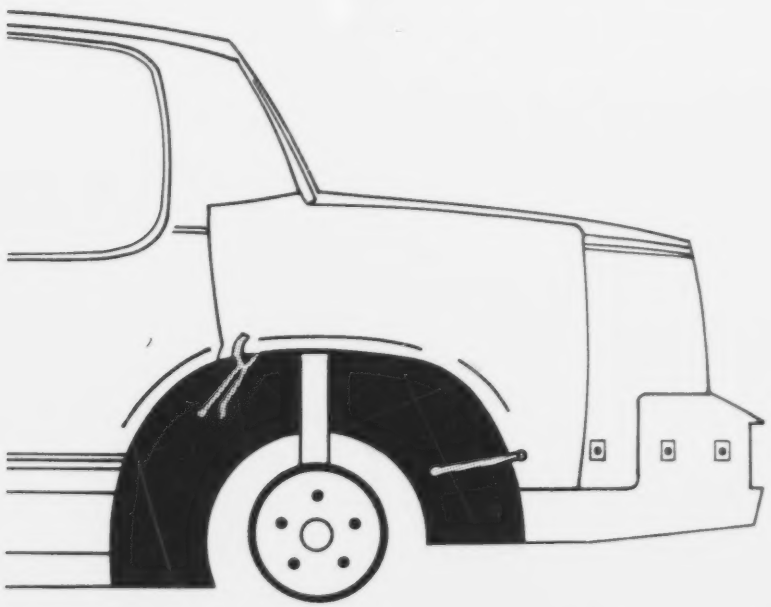
F. Cut replacement panel to fit damaged area, allowing approximately 3/4 of an inch overlap along all edges to be welded

G. Check fit and adjust as necessary

H. Remove paint and other coverings from surfaces to be welded

I. Put panel in place, align, and clamp (Figure 12)

FIGURE 12



J. Weld panel in place using appropriate methods for type of metal and installation

(NOTE: Sections will generally be spot welded or MIG welded. However, various methods may be required for a particular installation, depending on the adjoining surfaces. For example, joints along door pillars or deck lid contours may require braze welding or other processes.)

K. Fill welded areas and prepare section for refinishing

L. Clean work area and put away tools and equipment

REPLACE STRUCTURAL PANELS
UNIT IV

JOB SHEET #2 — REPANEL A DOOR

I. Tools and equipment

A. Mechanic's hand tool set

B. Door handle remover tools

C. Body grinder and goggles

D. Finish hammer

E. Dolly block

F. Special door edge crimping tool

G. MIG welding unit

H. Drill 1/4 inch

I. Drill bit set

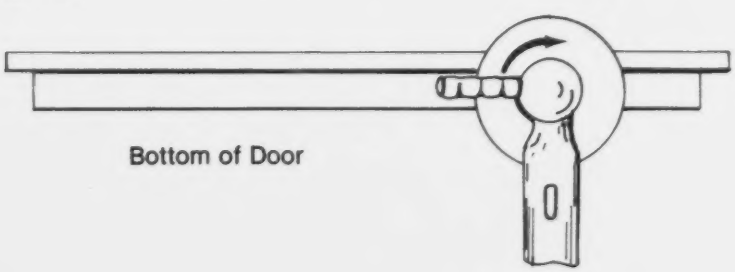
J. Alignment punch set

II. Procedure

A. Remove interior and exterior trim

B. Grind the edge of the door to cut the outer panel loose (Figure 13)

FIGURE 13



CAUTION

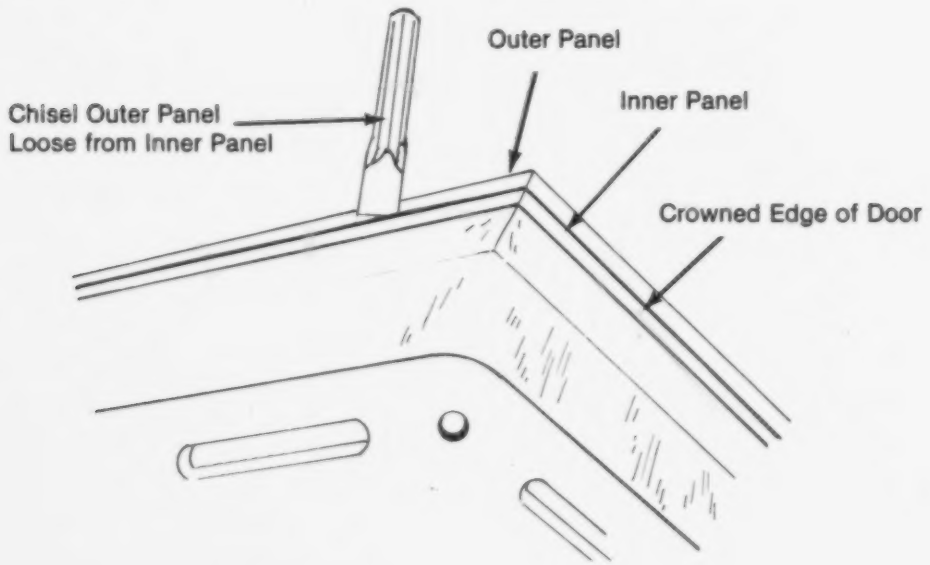
Wear goggles and disc away from other persons. This type of discing is very dangerous. Be sure you use the right techniques to prevent injury to yourself and others.

JOB SHEET #2

C. Chisel outer panel loose from inner panel

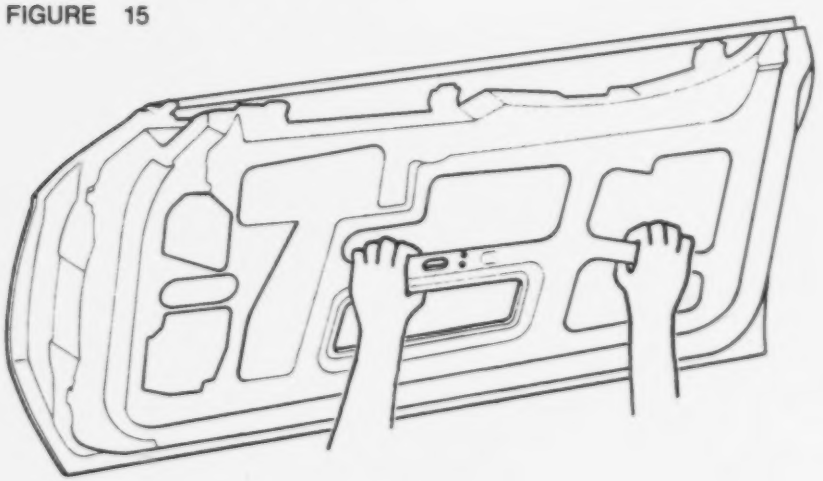
1. Grind all areas smooth
2. Align edges using hammer and dolly (Figure 14)

FIGURE 14



D. Reinstall inner panel (Figure 15)

FIGURE 15



JOB SHEET #2

1. Align inner panel
2. Straighten door facing

   (NOTE: Inner panel must fit perfectly or door will not fit when panel is installed.)

E. Remove door inner panel

F. Install replacement panel

1. Fit outer panel over inner panel

   (NOTE: Panel must fit perfectly.)

2. Flange outer panel over inner panel

FIGURE 16 (Hammer and dolly method)

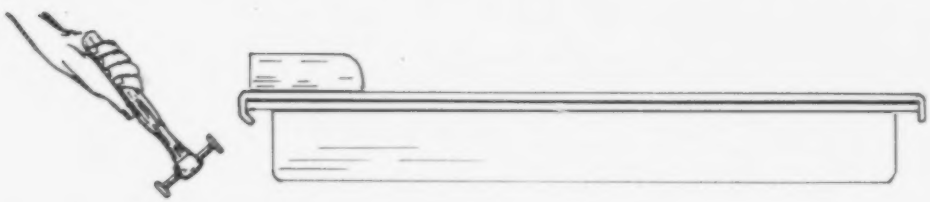
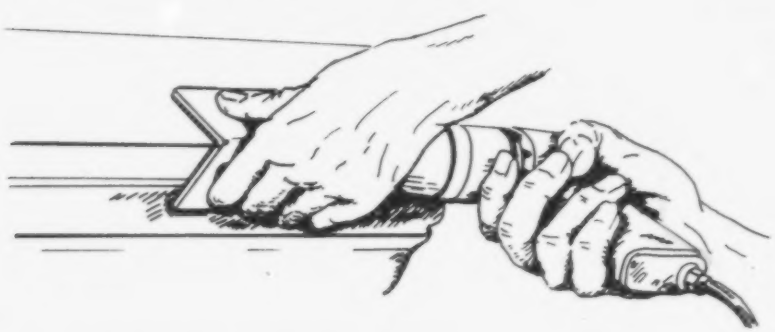


FIGURE 16 (Pneumatic tool method)



G. Check door alignment and adjust

H. Spot weld edges and corners

I. Weld corners

JOB SHEET #2

J. Braze areas between corners

K. Seal joints with seam sealer

L. Prime and finish areas

M. Install any weatherstrip or parts that had to be removed

N. Adjust door alignment

O. Install exterior and interior moldings and trim

P. Clean work area and put away tools and materials

REPLACE STRUCTURAL PANELS
UNIT IV

JOB SHEET #3 — REPLACE AN OUTER ROCKER PANEL

I. Tools and equipment

A. Mechanic's hand tool set

B. Body hammers

C. Dolly blades

D. Frame and body straightening unit

E. Hydraulic jack set

F. MIG welding unit

G. Lift jack and safety stands

H. Pry bars

I. Alignment puncher

J. Body fillers (solder or plastic)

K. Seam sealers and undercoats

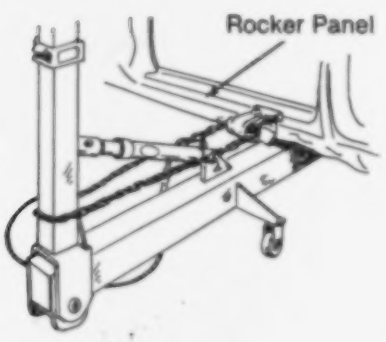
II. Procedure

A. Remove parts that will interfere with repair operations

EXAMPLES:
1. Doors
2. Step plates
3. Seats
4. Floor mats
5. Upholstery
6. Other items

B. Pull out damage (Figure 17)

FIGURE 17



JOB SHEET #3

1. Roughout floor
2. Roughout inner rocker panel

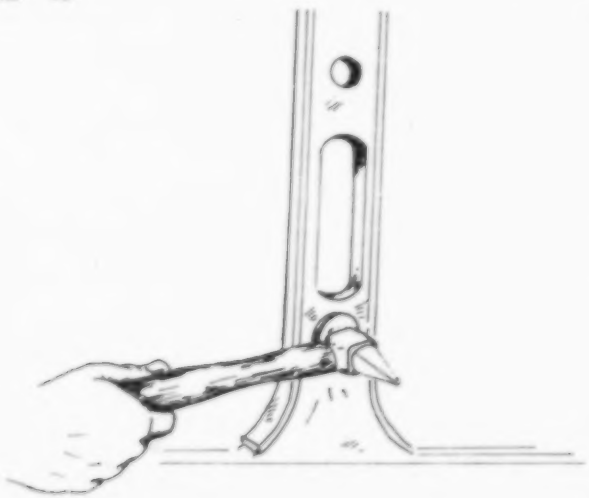
C. Use pneumatic cutter to cut out damaged outer panel

CAUTION

Do not use a cutting torch unless there is no other way. Fire danger is very high in this operation.

D. Straighten inner reinforcing panels (Figure 18)

FIGURE 18



E. Strip outer panel metal from pinch weld and other spot weld areas

1. Grind smooth
2. Align edge with hammer and dolly block

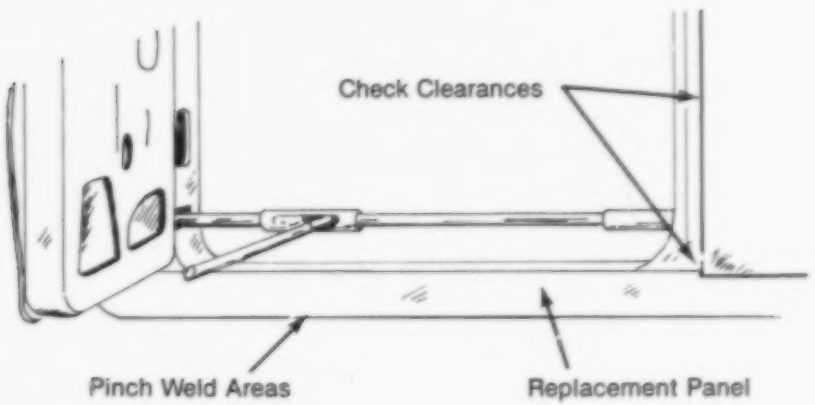
F. Fit new panel

1. Place panel in opening and clamp with locking pliers
2. Check alignment of inner panels and pinch weld areas

JOB SHEET #3

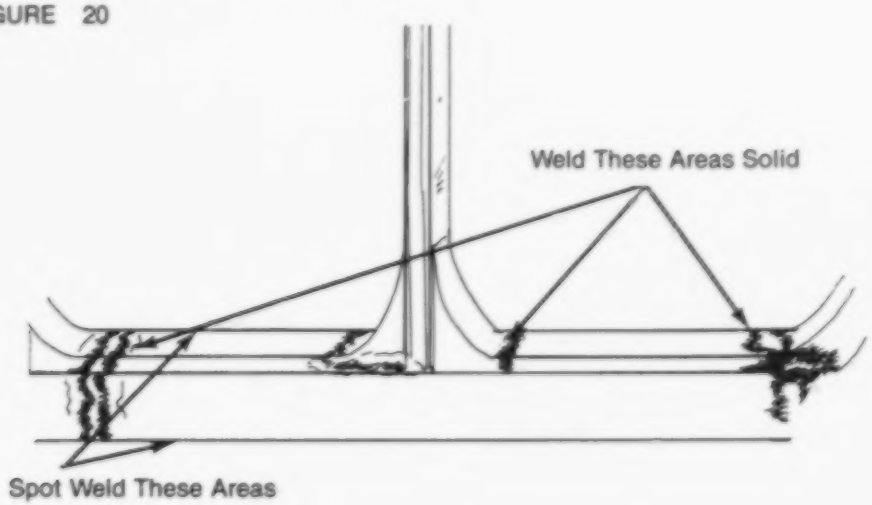
3. Check alignment with doors in openings to insure proper clearance (Figure 19)

FIGURE 19



G. Spot weld and finish the panel (Figure 20)

FIGURE 20



1. Spot all corners and several areas around the panel (use spot setting)
2. Spot around entire panel every one-half inch (use spot setting)

JOB SHEET #3

3. Weld panel ends shut
4. Grind, clean, and fill areas

   (NOTE: Use solder or body plastic filler.)

5. Finish the metal for painting

H. Clean work area and put away tools and equipment

REPLACE STRUCTURAL PANELS
UNIT IV

TEST

NAME _____ SCORE _____

1. Match to their correct definitions terms associated with replacing structural panels. Write the number of the term beside the correct definition.

_____a. To replace only the damaged portion of a body panel	1. Sectioning
_____b. The cutting and welding in of a panel to fit the damaged area	2. Flanging
_____c. Replacing part of the body as a unit	3. R and I
_____d. Remove and replace	4. Repanel
_____e. Remove and reinstall	5. Short cut
_____f. Replacing the outer panel (skin) of a door using the original inner door panel	6. R and R
_____g. Crimping the panel on a door with a hammer and dolly block or crimping tool	7. Body clip

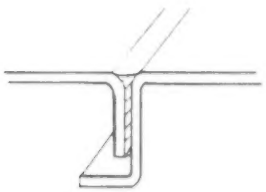
2. Match choices for correction of structural panel damage to their correct applications. Write the letter of the choice beside its correct application.

_____a. Used for minor damage or as a rough adjustment of major damage	1. Replace entire part
_____b. Used whenever replacement parts are available and the cost in time and money is less than other methods	2. Use filler to restore shape
_____c. Used for minor damage or to finish correction procedure for some other methods	3. Reshape part with force and/or heat in place
_____d. Used to repair damage that cannot be easily reshaped on parts that are difficult to remove or to find replacements for	4. Cut away portion of damaged part and replace with portion of another part

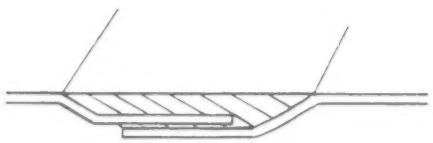
TEST

3. Identify types of structural panel welds. Write the correct name in the space provided by each illustration.

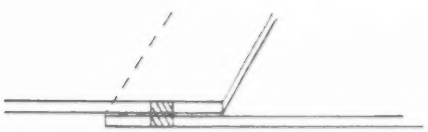
Spot welded lap joint
Fillet welded lap joint
Welded and filled lap joint
Crimped and welded lap joint
Pinch weld joint
Couch joint
Hemming joint
Gutter joint



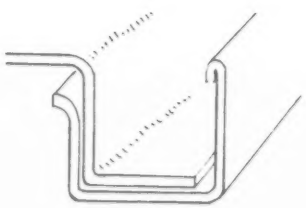
a. _____



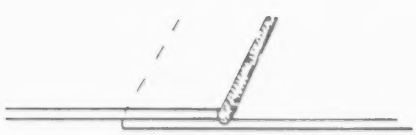
b. _____



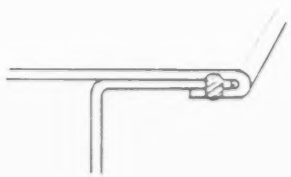
c. _____



d. _____

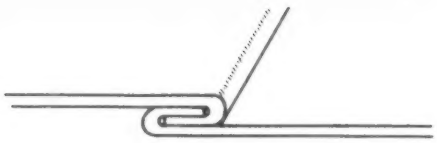


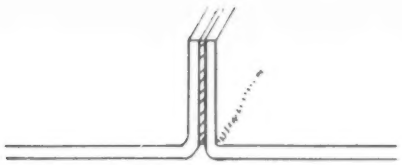
e. _____



f. _____

TEST





g. _____ h. _____

4. Select from a list methods of removing welded panels. Write an "X" beside each correct method.

   _____a. Panel cutter

   _____b. Cutting torch

   _____c. Plasma arc

   _____d. Drilling spot welds

   _____e. Hacksaw

   _____f. Hammer and chisel

(NOTE: Test item 5 lists the job sheets. They are an important part of this test. If they have not been completed, check with your instructor.)

5. Demonstrate the ability to

   a. Section a quarter panel.

   b. Replace a door skin.

   c. Replace an outer rocker panel.

REPLACE STRUCTURAL PANELS
UNIT IV

ANSWERS TO TEST

1. a. 5
   b. 1
   c. 7
   d. 6
   e. 3
   f. 4
   g. 2

2. a. 3
   b. 1
   c. 2
   d. 4

3. a. Couch joint
   b. Welded and filled lap joint
   c. Spot welded lap joint
   d. Gutter joint
   e. Fillet welded lap joint
   f. Hemming joint
   g. Crimped and welded joint
   h. Pinch weld joint

4. a, b, c, d, e, f

5. Performance skills evaluated to the satisfaction of the instructor.